Final

LONG-TERM GROUNDWATER MONITORING

REPORT: APRIL 2006

LONG-TERM MONITORING PROGRAM

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List of Abbreviations and Acronyms

ASTM	American Society for Testing and Materials
bgs	below ground surface
BMP	Basewide Monitoring Plan
BS	Burial Site
BTEX	benzene, toluene, ethylbenzene and xylene (total)
C	Celsius
CD	Compact Disk
CGI	combustible gas indicator
CHP	Central Heating Plant
COCs	chemicals of concern
CofC	chain of custody
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethene
DO	dissolved oxygen
EE/CA	Engineering Evaluation/Cost Analysis
EFDZ	Earthfill Disposal Zone
ES	Engineering-Science, Inc.
ESD	Explanation of Significant Differences
FAA-A	Further Action Area-A
FAA-B	Further Action Area-B
FP	Field Procedure
FS	Feasibility Study
FTA	Fire Training Area
GBT	gas barrier trench
GLTS	Gravel Lake Tanks Site
gpm	gallons per minute
GWOU	Groundwater Operable Unit
GWTS	groundwater treatment system
JP-4	Jet Propulsion Fuel – Type 4
IT	IT Corporation
LNAPL	light, non-aqueous phase liquid hydrocarbons
LEL	lower explosive limit
LFG	landfill gas
LF	Landfill
LTM	long-term monitoring
MCL	Maximum Contaminant Level
MS	matrix spike
MSD	matrix spike duplicate
MTBE	methyl tertiary-butyl ether
µg/L	micrograms per liter
mg/L	milligrams per liter
NPDES	National Pollutant Discharge Elimination System

List of Abbreviations and Acronyms (continued)

NTU	Nephelometric Turbidity Units
OAC	Ohio Administrative Code
O&M	Operation and Maintenance
ORP	oxidation reduction potential
OU	Operable Unit
PCE	tetrachloroethene
PID	photoionization detector
POL	petroleum, oil and lubricant
POTW	publicly owned treatment works
PWP	Project Work Plan
QA	quality assurance
QC	quality control
RASP	Removal Action System Performance
RG	remediation goal
RI	Remedial Investigation
ROD	Record of Decision
SOW	Statement of Work
SP	Spill Site
SPMP	System Performance Monitoring Plan
STL	Severn Trent Laboratories
TVH	total volatile hydrocarbon
TCE	trichloroethene
SCOU	Source Control Operable Unit
STL	Severn Trent Laboratories
UEL	upper explosive limit
USEPA	U.S. Environmental Protection Agency
VOA	volatile organic aromatics
VOC	volatile organic compound
WPAFB	Wright-Patterson Air Force Base

1.0 Introduction

This document presents the results of the quarterly field activities conducted in January 2006 and the quarterly, semiannual, and annual field activities conducted in April 2006 under the continuing long-term monitoring (LTM) program at Wright-Patterson Air Force Base (WPAFB), Ohio. The continuing quarterly, semiannual, and annual LTM program field activities consist of the following tasks:

- Semiannual groundwater monitoring in accordance with the Record of Decision (ROD) at Landfills 8 and 10 [Operable Unit (OU) 1];
- Quarterly soil gas and groundwater level monitoring at OU1.
- Monthly hydraulic containment monitoring at Landfill 5 (OU5);
- Quarterly Operation and Maintenance (O&M) landfill gas monitoring at Landfills 3, 4, 6, and 7 (OU4);
- Semiannual monitoring in accordance with the ROD at Spill Sites 2, 3, and 10 (OU2);
- Semiannual volatile organic compound (VOC) monitoring in accordance with the continued Basewide LTM program for groundwater removal actions; and
- Annual VOC and metals monitoring in accordance with the continued Basewide LTM programs for groundwater removal actions.

Each chapter contains a discussion of the various tasks, including the methods of data collection, variances from approved procedures based on field conditions, sampling results, and an evaluation of the results.

Each of the above tasks is presented in a stand-alone chapter that can be extracted from the compendium. With the exception of OU1 and OU2, which have separate RODs, all groundwater monitoring tasks are ultimately evaluated together under the Groundwater Operable Unit (GWOU) for all of WPAFB (discussed in Chapter 7.0). OUs 1 and 2 are discussed individually in Chapters 2 and 5, respectively. The GWOU was established under the Basewide Monitoring Plan (BMP) to provide a comprehensive method for monitoring and evaluating the individual source areas (OUs), plume migration, and the natural attenuation of contaminants.

1.1 WPAFB Location

WPAFB is located in southwestern Ohio, between the cities of Dayton and Fairborn, and occupies portions of Greene and Montgomery Counties (Figure 1-1). WPAFB is subdivided into three areas: A, B, and C (Figure 1-2). The installation was formed as a consolidation of two bases: Wright Field (Area B) and Patterson Field (Areas A and C). Area B is separated from Areas A and C by State Route 444 and the ConRail Corporation railroad tracks. Areas A and C encompass approximately 5,711 acres and Area B encompasses approximately 2,800 acres.

1.2 WPAFB GWOU Background Information

Through the Installation Restoration Program (IRP) WPAFB has grouped all confirmed or suspected sites requiring investigation and characterization into 11 geographically based source operable units, designated OUs 1 through 11 (Figures 1-3 and 1-4). Groundwater, surface water, and sediment contaminants from each of the 11 OUs and groundwater contaminants that are not attributable to a known source on WPAFB are combined to form the groundwater operable unit (GWOU). Also included in the GWOU are sites where Site Investigations (SIs) have been conducted. These sites include Further Action Area – A (FAA-A), FAA-B, and the former Building 59 and Buildings 79/95 Complexes (Figures 1-2 and 1-4). Because of groundwater movement patterns under WPAFB, contaminants from one source area may be transported through others, commingling contaminants and finally moving into remote portions of the Base. The BMP was established to evaluate contaminant movement, assess risks posed to human health and the environment by exposure to the contaminants, and design a remedy for groundwater throughout the Base (IT Corporation (IT), 1999a).

The GWOU is defined by three boundaries: an upper boundary, a lower boundary, and horizontal boundaries. The upper boundary consists of the water table surface, including the vertical zone of seasonal water table fluctuations. The lower boundary is the first occurrence of bedrock, which is at the base of the alluvial aquifer. The horizontal boundaries are the confines of WPAFB and also include the surrounding areas affected by off-site migration of contaminants from WPAFB.

1.3 Purpose and Objectives

The LTM program tasks are performed in accordance with the individual sampling programs that were previously being conducted concurrently at WPAFB. These sampling programs are summarized in the *Long-Term Groundwater Monitoring Report: October 1998* (IT, 1999b).

Data collected as part of the LTM will form a data set to be used to evaluate trends in the organic and inorganic chemicals of concern (COCs) in groundwater and to evaluate the progress of ongoing remedial actions throughout WPAFB. Specific objectives of the LTM program are:

- Provide data to monitor past detections of inorganic COCs above the Maximum Contaminant Levels (MCLs) at WPAFB that do not appear to form congruent contaminant plumes.
- Provide data to monitor areas of WPAFB where groundwater concentrations of VOCs exceed MCLs.
- Provide monitoring data in accordance with the recommended action for Further Action Area-B (FAA-B) [vinyl chloride contaminated site adjacent to the drum storage facility at Building 92, Area B, and east of Spill Site (SP) 11] to evaluate current conditions. Sampling will be conducted annually.
- Provide monitoring data to verify the progress of ongoing remedial efforts in accordance with the RODs for OU1 and OU2.
- Provide methane monitoring at OU4 to evaluate the progress of the selected remedy in accordance with the *OU4 Landfill Gas Monitoring Technical Memorandum* (CH_2M HILL, 1998).
- Provide monthly groundwater elevations and semiannual groundwater quality data for monitoring downgradient of OU5 [Further Action Area-A (FAA-A)] to evaluate the horizontal and vertical groundwater flow and capture zones and, ultimately, the effectiveness of the extraction system.

1.4 Basewide Monitoring Program

Numerous groundwater contamination investigations have been undertaken at WPAFB. A synopsis of environmental studies performed on the Base as a whole and those performed on specific OUs can be found in Table 2-1 of the *Final Engineering Evaluation/Cost Analysis* (EE/CA) Groundwater Basewide Monitoring Program (IT, 1999a). Expanded discussions of the results of these studies are provided in other documents that delineate the extent of contamination at the different OUs. As such, the COC sources and likely pathways for contaminant migration are well defined.

The EE/CA was prepared to determine groundwater remedial actions under the BMP. It evaluated reasonable remedial action alternatives for the GWOU that would be protective of human health and environment by mitigating groundwater contamination. Based on a

comparative evaluation of the alternatives presented in the EE/CA and/or GWOU ROD, the following actions were recommended:

- Area C, FAA-A: Continue current groundwater treatment, discharge to surface water, monitoring, and restrictive regulations. Provide monthly groundwater elevations and semi-annual groundwater quality data for monitoring downgradient of OU5 (FAA-A) to evaluate the horizontal and vertical groundwater flow and capture zones and, ultimately, to evaluate the effectiveness of the extraction system. A treatability study consisting of a chemical oxidation pilot-test at EW-1 was conducted during the spring of 2000.

- Area B, FAA-B: Continue annual groundwater monitoring to monitor for the potential migration of VOC contamination. A treatability study consisting of a chemical oxidation pilot-test was conducted during the fall of 1999. It was determined that the source area was above the water table and could not be remediated with Fenton's Reagent. Soil excavation was recommended. In October 2000, approximately 200 cubic yards of soil, located within the fence line of Facility 92, was removed. Additional long-term monitoring was implemented to observe the effects of the remedial action.

The selected remedy for the remainder of the GWOU consists of LTM for those areas that meet the following criteria:

- Have existing remedies in place (OU1 and OU2);
- Exceed MCLs for organic COCs, but do not exceed the target risk range;
- Exceed a cumulative cancer risk of 1×10^{-4} or a hazard index of 1 for organic COCs, but do not exceed MCLs; and
- Exceed MCLs and background concentrations for inorganic COCs.

The LTM program is being conducted in these areas to: (1) confirm that the conclusions drawn in the EE/CA are valid; (2) ensure that appropriate actions can be implemented if monitoring indicates that organic COCs are migrating; and (3) confirm that the stated remedial action objectives are met.

Also included in the LTM program are monitoring wells at the former Building 79/95 Complex and former Building 59. As recommended by Ohio EPA (OEPA) and presented in the *Building 79/95 SI Report* (Shaw, September 2005), groundwater was sampled for VOCs under the LTM program to provide continued monitoring surveillance of the TCE plume at the site. With the continued concentrations of TCE in the groundwater (above the MCL: 5 µg/L) the Area of

Concern groundwater will continue to be monitored semiannually for VOCs under the LTM program until specific documentation is provided formalizing the addition or deletion of any wells from the LTM and GWOU Record of Decision.

In accordance with the "Potential Remedial Alternatives" section of the *Site Investigation Report for Building 59* (IT, 2001) the monitoring wells at former Building 59 were sampled as part of the LTM program to monitor the TCE contamination in groundwater. Groundwater at the site has been monitored for VOCs semiannually since October 1998. Groundwater at former Building 59 continues to be above the MCL for TCE (5 µg/L) in one well and the monitoring wells are currently undergoing review for further monitoring under the GWOU.

The Baseline sampling round for the Basewide LTM was conducted in April 1998 under the BMP and is considered the GWOU baseline data set for VOCs and metals. Data from subsequent sampling rounds has been compared to the LTM Baseline data to establish trends. Data from the Baseline sampling event was presented in the *Final Long-Term Groundwater Monitoring Baseline Report, Basewide Monitoring Program* (IT, 1999c). The wells selected for Baseline sampling were recommended in the EE/CA, with the exception of the wells that were being monitored under existing sampling programs associated with remedial actions in OU1, OU2, and OU5.

1.5 Organization of the LTM April 2006 Report

Monitoring procedures, results, and data evaluation for the January and April 2006 Basewide LTM program monitoring events are presented in the following chapters.

- Chapter 2 describes the quarterly and semiannual sampling conducted in accordance with the ROD for Landfills 8 and 10 (OU1). Activities conducted as part of the OU1 ROD requirements include quarterly treatment system effluent sampling, quarterly landfill gas and hydraulic containment monitoring, and semiannual monitoring well sampling. Chapter 2 also presents a summary of the sampling results, a discussion of the landfill gas monitoring results, a description of the hydraulic containment monitoring results, and an evaluation of the performance of the OU1 remediation system.

- Chapter 3 describes the hydraulic containment monitoring being conducted at OU5. Monthly groundwater level elevations provide a continuous evaluation of the extraction system and the hydraulic flow conditions at OU5.

- Chapter 4 describes the landfill gas monitoring activities at OU4, including a summary of the scope of work and site description/history, monitoring procedures, and monitoring results.

- Chapter 5 presents the field activities and the analytical results from the semi-annual sampling conducted at OU2. Field activities consisted of soil gas monitoring and groundwater sampling. Also presented is an overview of the natural attenuation of petroleum hydrocarbons being monitored at OU2.

- Chapter 6 describes the Basewide LTM groundwater monitoring activities and presents the semiannual and annual groundwater sampling results.

- Chapter 7 presents an evaluation of the Basewide LTM groundwater analytical results.

- Chapter 8 provides a list of the references used throughout the document.

Appendices:

- Appendix A presents summaries of OU1, OU2, and LTM monitoring procedures, and brief site histories for areas where site investigations occurred separate from the LTM activities.
- Appendices B through K present field forms or analytical data.
- Appendix L presents the Mann-Kendall Trend Evaluation of LTM analytical Data.

2.0 Record of Decision (ROD) Sampling at Landfills 8 and 10 (OU1)

Chapter 2 presents the results of the quarterly monitoring and semiannual compliance groundwater sampling for OU1 at WPAFB, Ohio, conducted during the reporting period of November 2006 through April 2006. Quarterly monitoring was conducted in January and March 2006; compliance groundwater sampling was conducted in April 2006. Also, quarterly sampling of the leachate collection system discharge line was conducted in January and April 2006, to comply with the conditions specified in the City of Fairborn sewer discharge permit.

2.1 Introduction

The LTM program at OU1 was initiated in accordance with the *Record of Decision for Source Control Operable Unit - Landfills 8 and 10* (LFs 8 and 10) (WPAFB, 1993), *the OU1 Final Operations and Maintenance (O&M) Plan* (Kelchner, 1997) and the Amendment to the OU1 System Performance Monitoring Plan (SPMP) (IT, 2000a). The information presented in this report is the result of fieldwork conducted as part of the O&M Plan and Performance Monitoring. A description of LFs 8 and 10 is summarized in the Long-Term Groundwater Monitoring Report: October 1998 (IT, 1999b); the landfill site vicinity is depicted in Figure 2-1. The sampling frequency and the schedule for OU1 wells are defined in Table A1-1 of Appendix A1. Figures 2-2 and 2-3 present the locations of the selected perimeter monitoring wells at LFs 8 and 10, respectively.

The OU1 monitoring program includes quarterly monitoring of landfill gas (methane) and groundwater levels, and annual and semiannual compliance groundwater sampling. The objectives of the OU1 monitoring programs are presented in Appendix A2. Overall, data collected as part of the OU1 LTM program form a data set that is used to evaluate the progress of the ongoing remedial efforts at OU1 and determine whether the selected remedy identified in the ROD continues to be protective of human health and the environment.

2.2. OU1 Compliance Groundwater Monitoring

OU1 compliance groundwater monitoring was conducted from April 4 through April 20, 2006. Samples were collected and analyzed for VOCs and total metals in accordance with the procedures presented in Section 6.3.2 of the OU1 Final O&M Plan (Kelchner, 1997) and summarized in Appendix A2. Groundwater sample handling and management, field quality assurance samples, and analytical methods are also presented in Appendix A2. Analytical parameters, collection

frequency, and sample handling criteria for the OU1 annual and semiannual sampling events are presented in Table A2-1 of Appendix A2.

2.2.1 Groundwater Sampling Procedures

The monitoring wells were purged and sampled with dedicated bladder (pneumatic) pumps using the micropurge method. Procedures and sampling criteria for the micropurge method are described in detail in Appendix A2. Groundwater quality was considered representative of the surrounding geologic formation when the field parameters had stabilized. The monitoring well purge logs for sample collection are presented in Appendix B1 on the enclosed field forms CD. Field parameters measured just prior to sampling are presented in Table 2-1.

During the April 2006 monitoring event monitoring wells LF08-MP013, LF10-MW03A, LF10-MW02 and LF10-MW104 were dry. Soil vapor monitoring point LF08-MP13 was incorporated into the OU1 groundwater monitoring network to further monitor VOC concentrations in groundwater along the northeastern corner of LF8. This location was identified as potentially having elevated VOC concentrations in groundwater when TCE was detected in soil vapor samples collected during the July and October 2001 monitoring events (*Final Long-Term Monitoring Report: October 2001* [IT, 2002a]). Groundwater has been sampled semiannually from this point since May 2002. Any further monitoring is currently under review.

2.3 OU1 Landfill Gas Monitoring

The permanent OU1 landfill gas monitoring probes, punchbar monitoring points, and LF10 gas barrier trench (GBT) are monitored quarterly in accordance with the OU1 Source Control ROD (WPAFB, 1993). Landfill gas monitoring is performed to determine the effectiveness of the collection system in establishing a capture zone that extends outside the landfill boundaries. The existing landfill gas monitoring probes and permanent punchbar locations at LFs 8 and 10 are located within the surrounding Base residential property lines to monitor for potentially migrating landfill gas (Figures 2-4 and 2-5, respectively). In addition to the monitoring probes and punchbar locations, the GBT, located east of LF10, is monitored (Figure 2-5). A complete description of the landfill gas monitoring procedures is presented in Appendix A2.

2.4 Effluent Collection System Monitoring

To comply with the conditions specified in the City of Fairborn sewer discharge permit, one effluent sample per quarter is collected from the discharge line of the effluent collection system.

Sampling procedures, analytical parameters and handling criteria for the leachate collection system discharge line sample are presented in Appendix A2.

In addition to reporting the effluent analytical data semiannually in the April and October LTM reports, quarterly reports are submitted to the WPAFB project manager and to the City of Fairborn Water Projects Coordinator. The January and April 2006 letter reports are presented in Appendix C3.

2.5 OU1 Compliance Monitoring

The following sections summarize the analytical results from the April 2006 sampling event at LFs 8 and 10. Table 2-2 presents the laboratory reporting limits for the April 2006 sampling event and the compliance levels established in the OU1 Source Control ROD (WPAFB, 1993). The MCLs are also provided for information purposes. Appendix C contains the full laboratory analytical reports and the chain of custody (CofC) records for the OU1 samples. Analytical results for the April 2006 sampling event at LF8 and LF10 are presented in Appendix C1 in "detects only" format. Full analytical reports, including case narratives, are provided on the enclosed Analytical Data CD.

2.5.1 Landfill 8 Analytical Results

Tables 2-3 and 2-4 present summaries of the LF8 VOC and total metals analytical data, respectively. In addition to the April 2006 sampling results, data from previous sampling events have been included in the tables. Analytical data for VOCs and total metals analyses at LF8 are presented in Appendix C1 in "detects only" formats. Full analytical reports, including case narratives, are provided on the enclosed analytical data CD. Figure 2-6 presents the concentrations of the detected COCs at LF8 for April 2006, with concentrations exceeding MCLs and/or ROD compliance levels denoted in red.

The only VOC detected above a compliance level or MCL was vinyl chloride. Vinyl chloride was detected in wells 02-DM-83S-M and LF08-MW10B at concentrations of 3.2 and 5.0 µg/L, respectively. Monitoring point LF08-MP13 was dry during the April 2006 monitoring event.

In accordance with requirements presented in the revised WPAFB QAPP (Shaw, 2006), the Mann-Kendall Trend Evaluation was performed on groundwater data from two monitoring locations in the vicinity of OU1 (Appendix L). These locations are monitoring wells LF08-MW10B and 02-DM-83S-M and both have elevated vinyl chloride concentrations. Results of the evaluation on

these wells indicate that vinyl chloride concentrations are overall consistent with historical levels and indicate that the concentrations in these wells are "stable" (Table L-1).

Arsenic was detected in wells LF08-MW02C (52 µg/L), LF08-MW08B (11 µg/L), LF08-MW101 (13 µg/L) and 02-DM-81D-M (25 µg/L) and was the only inorganic parameter to exceed an MCL (10 µg/L).

2.5.2 Landfill 10 Analytical Results

The April 2006 VOC and inorganic (total metals, cyanide and ammonia) analytical data for LF10, are summarized in Tables 2-5 and 2-6, respectively. In addition to the April 2006 analytical results, data from previous sampling events have also been included. Figure 2-7 presents the concentrations of the detected COCs at LF10 for the April 2006 sampling event, with concentrations exceeding MCLs and/or ROD compliance levels denoted in red. There were no VOCs detected in the LF10 monitoring well network during the April 2006 sampling event.

Arsenic was detected in wells LF10-MW09C (10 µg/L) and 01-004-M (82 µg/L) and was the only inorganic parameter to exceed an MCL (10 µg/L).

2.5.3 Effluent Collection System Sample

Quarterly sampling of the OU1 effluent collection system discharge line was conducted in January and April 2006. One sample from each quarter was analyzed for VOCs, inorganics, oil and grease, total suspended solids, chemical oxygen demand, and pH. All concentrations of the detected parameters were below City of Fairborn requirements. Analytical results for the January and April 2006 effluent samples are presented in Appendix C1 in "detects only" format and in the City of Fairborn letter report (Appendix C3). Full analytical reports, including case narratives, are provided on the enclosed Analytical Data CD.

2.6 OU1 Landfill Gas Monitoring

The following section presents an overview of the landfill gas monitoring at OU1. Landfill gas monitoring was conducted on January 26 and March 30, 2006. Procedures and locations for landfill gas monitoring at LFs 8 and 10 are presented in the System Performance Monitoring Plan (SPMP) of the OU1 Final O&M Plan (Kelchner, 1997) and in the *Methane Gas Migration Study Summary Report* (Engineering-Science, Inc. [ES], June 1991). Landfill gas monitoring procedures are also summarized in Appendix A2 of this report. The field logs are presented in Appendix B2.

2.6.1 LF8 Landfill Gas Monitoring Results

LF8 landfill gas monitoring locations are presented on Figure 2-4. During both the January and March 2006 monitoring events, methane/explosive gas was detected at monitoring point LF08-MP010. During the January event, methane was detected at a concentration of 47.6% by volume (Table 2-7), which is greater than 100% of the lower explosive limit (LEL). During the March sampling event methane was detected at a concentration of 49.9%, which is also greater than 100% of the LEL. Table 2-7 presents the history of elevated methane/explosive gas detections for this location. The January and March sustained readings for probe LF08-MP010 remained greater than 100% of the LEL. During the January event, methane was detected at monitoring point LF08-MP011 at a concentration of 2.7% by volume, which is 27.0% of the LEL. During the January event, no groundwater was pulled into the sampling line of the LF8 monitoring points. During the March event, groundwater was pulled into the sampling line at three of the monitoring points.

To ensure that methane is not migrating into the adjacent houses or surrounding utility lines, "punchbar" monitoring locations (manually driven, 1/2-inch boreholes) are also monitored quarterly. Punch bar locations are shown on Figure 2-4. As summarized in Table 2-7, methane/explosive gas was not detected at these four locations during this reporting period. Methane was not detected at any of the LF8 punch bar locations.

2.6.2 LF10 Landfill Gas Monitoring Results

LF10 landfill gas monitoring locations and the GBT are presented on Figure 2-5. Methane was not detected at any of the eight monitoring probes or fourteen punch bar locations. At the GBT methane was not detected at the north end (GBT0N) during the January monitoring event. At the south end of the GBT (GBT0S) methane was detected at a concentration of 5.6% (>100% LEL). During the March monitoring event, methane was not detected at the north end of the GBT. Methane was detected in the south end at a concentration of 26.6% (>100% LEL). Table 2-8 presents the results of the January and March 2006 monitoring results and the previous two years of monitoring results.

2.7 Water Level Monitoring and Evaluation

Quarterly groundwater levels are measured to evaluate the effectiveness of the extraction system in lowering water levels in the vicinity of the landfills. A discussion of the objectives and procedures for water level monitoring are presented in Appendix A2. Figures 2-2 and 2-3 show the locations of monitoring and extraction wells used to measure groundwater levels at LF8 and

LF10, respectively. The coordinates of the LF8 and LF10 wells, their reference points, screen intervals, and water levels are provided in Tables 2-9 and 2-10, respectively. In addition, the tables also indicate the flow-totalizer (QED, Inc.) readings for the number of pumping cycles the well pump have performed. Each cycle represents 0.5 gallons pumped and the numbers indicate the total volume pumped since installation. OU1 groundwater level monitoring logs for January and March 2006 are presented in Appendix B3.

To interpret the groundwater elevations at each landfill, groundwater contours were generated using SURFER™, a computer contouring package (Golden Software, Inc.). The contours were generated by first overlying a grid on the landfill. Hydraulic head values at the grid nodes were then computed from the measured values using linear kriging, an interpolation option in SURFER™. To simulate contaminant movement through the subsurface particle tracks were generated using Environmental Visualization Software (C Tech Development Corp.) using the kriging method. Groundwater contouring and particle track generation methods are discussed further in Appendix A2, Chapter 5.

2.7.1 Landfill 8 Groundwater Capture Evaluation

Table 2-9 presents the water level elevations for the LF8 hydraulic containment monitoring well network for January 25 and March 29, 2006. Figures 2-8 and 2-9 illustrate the resultant LF8 groundwater surface elevation contours and particle track flow paths for January 2006, respectively. During January the groundwater contours do not show curvature around extraction well EW-0807 that would indicate flow to the well and the creation of a capture zone in the central portion of LF8 (Figure 2-8). To illustrate the capture zones for each well, particle tracks were created from the groundwater elevation contours and flow directions. The particle tracks shown in Figure 2-9 represent particles released along the topographic high point of LF8 and indicate the paths they travel through the landfill. The January particle tracks indicate capture reasonable capture is occurring in the landfill. In the central portion of LF8, well EW-0810 has created a capture zone for upgradient particles, including some particles originating upgradient of EW-0807. The water level in well EW-0807 is lower than in downgradient well LF08-MW102, and is likely providing some capture although not graphically indicated by the particle tracks. At the southern end of LF8 the cumulative pumping of wells EW-0801, EW-0803, and EW-0805 creates flow toward a central low grid point near well EW-0805.

Groundwater elevation contours and particle track flow paths for March 2006 are presented in Figures 2-10 and 2-11, respectively. As seen in the March 2006 particle tracks on Figure 2-11,

complete groundwater capture is occurring in the central and southern portions of the LF8 model grid. To illustrate the subsurface and dynamic water levels at eastern boundary of LF8, a geologic cross section along line A-A' (Figure 2-2) has been created. Figure 2-12 presents the geologic profile through this portion of LF8 and the water table surface on March 29, 2006. The cross-section also shows the proximity of the water table to the bottom of the fill material.

2.7.2 Landfill 10 Groundwater Capture Evaluation

Landfill 10 represents a local hydrologic high where groundwater from outside the landfill does not contribute substantially to leachate generation. The objective of the extraction system at LF10 is to maintain groundwater levels below the bottom of the landfill to prevent water from mixing with the in situ waste at the landfill. By controlling the groundwater levels, the impact of the LF10 leachate on the groundwater environment is minimized.

The effectiveness of the LF10 extraction system is evaluated by comparing the elevation of the water table to the elevation of the landfill bottom. The system is achieving the stated goal as long as the water table is below the landfill bottom. If that occurs, any verification of the radius of influence for the extraction wells is not necessary. The extraction wells serve the purpose of lowering the water table rather than creating a capture zone under LF10. Water level elevations for the entire LF10 hydraulic containment monitoring well network for January and March 2006 are presented in Table 2-10 and are shown as contours on Figures 2-13 and 2-14, respectively. The water level elevation contours were generated from the extraction wells and monitoring wells screened at the approximate same depth as the extraction wells.

To examine the effectiveness of each extraction well, historic water level elevations and the landfill bottom elevation were compared on well hydrographs (Figures 2-15 through 2-24). Landfill bottom elevations were determined from extraction well installation notes and the drilling reference point elevations (Table 2-11). The graphs show the varying fluctuations in water levels from one sampling event to another since January 2000. Well EW-1003, in the southern portion of LF10, has recently been repaired and has kept the water level below the bottom of the fill material the past two quarters (Figure 2-16).

The hydrographs show that all extraction well water levels were below the bottom of the landfill for the past two quarters. To illustrate the subsurface and dynamic water levels along the central portion of LF10, a geologic cross section along line A-A' (Figure 2-3) has been created. Figure 2-25 presents the geologic profile through LF10 and the water table surface on

March 29, 2006. This profile provides an indication that groundwater levels are below the base of the landfill.

2.8 Conclusions

During this monitoring period, groundwater capture was achieved consistently in the central and southern portions of the LF8 eastern boundary thus providing hydraulic containment in this area. Along the northern portion of the LF8 eastern boundary, downgradient groundwater flow capture was not occurring during a portion of the reporting period. Wells EW-0812 and EW-0816 were not operating effectively during the March monitoring period. These wells have reoccurring mechanical problems and continue to be evaluated and repaired. The LF8 geologic profile (Figure 2-12) shows the March 2006 groundwater level relative to the known landfill material. As seen in the figure, groundwater is not in contact with the bottom of the fill material. This figure also depicts the approximate pump location for most of the LF8 extraction wells. The pumps in wells EW-0807 and EW-0812 appear to be placed at a higher elevation than the pumps in the surrounding wells. Thus, measured water elevations at these locations are consistently higher than the surrounding extraction wells. Since the April 2006 water levels at LF8 and the completion of this Draft report, several repair and maintenance activities have been performed on the pumps and appurtenances in wells EW-0812 and EW-0816. The repairs and maintenance activities performed by Tetra Tech, Inc. are detailed within the monthly Operations & Maintenance reports.

The wells that comprise the OU1 monitoring well network are currently being evaluated for optimization. Statistical analysis is utilized as part as the decision process.

At LF10 the extraction system maintained the water levels below the landfill bottom at all 16 extraction wells during this monitoring period.

3.0 OU5 Monthly Hydraulic Containment Monitoring

This chapter presents the OU5 hydraulic containment monitoring procedures and results conducted under the LTM program at WPAFB (Figure 3-1) during the reporting period of November 2005 through April 2006.

3.1 Introduction

The main function of the groundwater treatment system (GWTS) at OU5 is to contain the potential migration of the initial VOC plume emanating from LF5. The VOC plume was defined during the OU5 RI and is presented in the OU5 RI report (IT, 1995a). Monthly hydraulic containment monitoring at OU5 was conducted in accordance with the *OU5 System Performance Monitoring Plan* (SPMP) (IT, 1992) and the *Final Addendum No. 1 to the Landfill 5 SPMP, Basewide Monitoring Program* (IT, 1999d) to evaluate the effectiveness of the groundwater extraction system in preventing the VOC migration beyond the Base boundaries. The program currently consists of monthly water level monitoring at 42 wells (41 monitoring wells and one extraction well [EW-1]) and five piezometers. Included in the 41 monitoring wells are selected wells owned by the City of Dayton. The five piezometers were installed in June 2003 around Twin and Gravel Lakes to help define the aquifer characteristics near the lakes during the aquifer recovery test at OU5. Figure 3-2 shows the locations of the 42 wells and five piezometers that comprise the current OU5 monitoring well network. The current well network is an expansion of the original monitoring network presented in the initial SPMP (IT, 1992). A more detailed description of OU5 is presented in Appendix A4.

3.2 Water Level Monitoring

The main purpose of extraction well EW-1 is to maintain a capture zone that prevents downgradient migration of contaminated groundwater from the LF5 area. To evaluate the effectiveness of EW-1 in containing groundwater in the vicinity of the site, OU5 groundwater elevations were calculated from water level measurements (Table 3-1) and contoured. OU5 water level monitoring field logs are presented in Appendix D.

Figures 3-3 through 3-8 show the monthly water level contours for the OU5 monitoring wells and extraction well EW-1 during the period of November 2005 through April 2006. Groundwater contours were generated using SURFER (Golden Software, Inc.), a grid-based contouring and three dimensional surface plotting graphics program. A summary of the contouring and groundwater flow modeling procedures is presented in Appendix A4.

3.3 Groundwater Capture Zone Analysis

The primary mechanism of contaminant transport is advection, i.e., a process by which moving groundwater carries dissolved solutes. Thus, understanding the groundwater flow pattern is the first step in an analysis of contaminant transport. The aquifer throughout OU5 is considered to have the same groundwater flow properties regardless of direction (isotropic). In an isotropic aquifer, the flow lines are perpendicular to the equipotential lines (groundwater elevation contours). In addition to the isotropic assumption, the aquifer is also assumed to have the same hydrologic properties throughout the model area (homogeneous).

Water level elevation contours and velocity vectors were generated in SURFER by creating a grid over the model area. The velocity vectors shown on Figures 3-3 through 3-8 indicate that groundwater flow across the eastern portion of LF5 is toward the southwest. The length of a velocity vector is proportional to the actual groundwater velocity. At the western boundary of LF5, groundwater flow is drawn toward EW-1, creating a capture zone.

The relatively long velocity vectors and the closely spaced water level contours upgradient from the extraction well indicate that EW-1 is "pulling" water from beneath the landfill. Downgradient from EW-1, the water level contours are widely spaced and the velocity vectors are relatively short, indicating that EW-1 is inhibiting downgradient groundwater flow.

The monthly capture zones created by EW-1 can also be defined by the particle tracks migrating through the landfill as shown on Figures 3-9 through 3-14. Groundwater particle tracks were created with Environmental Visualization Software (C Tech Development Corp.) using the kriging method to develop a potentiometric surface of groundwater head from the data, followed by a gradient calculation that plots streamlines. Particles were released along the upgradient (east) boundary of LF5 at the beginning of each of the streamlines to illustrate the potential downgradient migration pathlines of contaminants.

EW-1 operated effectively during the reporting period of May through October 2005 except for some short periods. Interruptions in service occurred during the following periods: May 19 – 22, power outage; June 8 – 14, power outage; and October 20 – 27 and 29 – 31, power outage and high sump/PSI alarm.

The water level elevations and particle tracks for the reporting period represent normal operating conditions for EW-1. As seen in Figures 3-9 through 3-14, groundwater particles released from the

entire upgradient perimeter of LF5 are being captured by EW-1 creating a hydraulic boundary for LF5. Wells downgradient of LF5 that may be possibly impacted by intermittent capture are monitored semiannually. Since the installation of EW-1, most VOC detections at these wells have decreased, confirming that capture is occurring. VOC concentrations at the furthest downgradient wells, MW132S and CW10-055, have remained at relatively steady state levels for the past ten years with only slight variations (see Section 6.0).

To further evaluate the groundwater flow pattern through OU5, reverse particle track plots were created for January and April 2006 of this reporting period to provide a comparison of seasonal variations if any. In reverse particle tracking, particles are released from their termination points and travel back to their origins. Figures 3-15 and 3-16 illustrate the reverse particle tracks for January and April 2006, respectively. As seen in the figures, a similar groundwater flow pattern can be seen over LF5 and on the downgradient side on the Huffman Preserve area of the Miami Conservancy District (MCD). Reverse particle track plots will also be created for July and October, and presented in the October LTM report to monitor any seasonal variations.

The patterns from both forward and reverse particle tracks show EW-1 continues to capture the defined VOC plume. VOC results from the downgradient wells (Chapter 6) indicate that only low concentrations of vinyl chloride (<1.0 µg/l) has been detected in the HD-13 wells, and 1,2-DCE (<1.0 µg/l) in CW04-060. The distance between these two locations is approximately 250 feet. In addition, the reverse particle tracks illustrate that particles originating from the southwest corner of LF5 pass near monitoring well CW10-055, which is sampled semiannually. As seen in the Figures 3-15 and 3-16, well CW10-055 is likely to be receiving some component of groundwater flow from the direction of well MW132S. Well MW132S has historically had consistent concentrations of TCE detected in the mid-20 ppb range. VOC concentrations in these wells are further discussed in Chapters 6 and 7.

3.4 OU5 VOCs Removed

Complete system performance reports on the groundwater treatment system (GWTS) pumping rates, system down time, repairs made, and estimated volume of VOCs removed from the extracted groundwater are compiled monthly for WPAFB by TetraTech, Inc. (Tetra Tech, 2006b) and presented in the *Monthly Progress Reports, November 2005 through April 2006, Landfill 5 Groundwater Treatment System* (TetraTech, 2005). Table 3-2 presents a summary of the monthly water quality analytical results, the total volume of water discharged and quantities of VOCs removed from the extracted groundwater at LF5 by the GWTS from November 2005 through April

2006. In summary, the GWTS extracted and treated a total of approximately 115.5 million gallons of water during the reporting period. During this reporting period, the OU5 GWTS removed approximately 21.5 pounds of the listed VOCs, of which approximately 17.8 pounds were trichloroethene (TCE). OU5 groundwater quality analytical data, monitored under the LTM program, is presented in Chapter 6.0 and discussed in Chapter 7.0.

3.5 Conclusions

Extraction well EW-1 continues to capture the defined VOC plume and provides a hydrodynamic barrier to contaminant migration over the majority of the western boundary. VOC contamination has not been detected above MCLs in the southwest corner of LF5. WPAFB believes that the southwest portion of LF5 is adequately monitored for potential contaminant migration. VOC results from the downgradient wells indicate that only low concentrations of vinyl chloride (<1.0 µg/l) has been detected periodically in the HD-13 wells, and 1,2-DCE (<1.0 µg/l) in CW04-060. When extraction well EW-1 has been operating consistently at approximately 545 gallons per minute (gpm) or greater over an extended period, a hydrodynamic barrier to contaminant migration is created over the majority of the western boundary of LF5. Groundwater flow patterns and the resultant particle tracks (Figure 3-3 through 3-16) indicate that EW-1 provided successful capture of potential contaminant particles under normal operating conditions during the entire reporting period.

The prolific aquifer in the OU5 area, comprised of coarse sands and gravel, allows for the water table to recover quickly to static conditions during periods when EW-1 is not pumping. However, even when EW-1 only operates intermittently, particles are still pulled towards EW-1. Potential contaminant migration from LF5 is monitored semiannually in downgradient City of Dayton wells HD-12S, HD-12M, MW131S, MW131M, HD-11, HD-13S and HD13D. Analytical results for these wells are presented and discussed in Chapters 6.0 and 7.0.

4.0 Landfill Gas Monitoring at OU4

Chapter 4 presents the results of the landfill gas monitoring at OU4.

4.1 Introduction

Landfill gas monitoring is conducted at OU4 in accordance with the *OU4 Landfill Gas Monitoring Technical Memorandum* (CH2M HILL, 1998) and the *Operation and Maintenance Plan Operable Unit 4 Landfills 3, 4, 6, and 7, and Drum Staging/Disposal Area* (CH2M HILL, 1997). This program includes quarterly monitoring of soil gas at Landfills 3, 4, 6, and 7 (OU4). The landfills are located on the southeastern boundary of Areas A and C, near the intersection of Skeel Avenue and Hebble Creek Road (Figure 4-1). The objective of this monitoring program is to evaluate the migration of landfill gas away from the landfills toward nearby structures. Data collected as part of this monitoring program is used to evaluate trends in the generation of landfill gas and to determine if a landfill gas collection system at OU4 will be necessary. Site background information, including a summary of the types of wastes that were historically disposed of at OU4 and a synopsis of the land use in the area, is presented in the *Remedial Investigation Report, Operable Unit 4, Landfills 3, 4, 6, and 7, and Drum Staging/Disposal Area* (CH2M HILL, 1994).

The landfill gas (LFG) monitoring network at OU4 consists of eight gas-monitoring wells (LG-1, LG-2, LG-3, LG-6, LG-7, LG-8, LG-9, and LG10) that are located around the perimeters of Landfills 3, 4, 6, and 7, and at locations inside Building 878 (Figure 4-2). Building 877, which has been removed, was a previous monitoring point located adjacent to monitoring point LG-10. This area is now an open lot. Landfill gas measurements were taken on January 2 and March 30, 2006. The field parameters of methane, LEL, carbon dioxide, and oxygen were measured using a LandTec GA-90 infrared gas analyzer.

4.2 OU4 Landfill Gas Monitoring Results

The January and March 2006 and historic LTM sampling results, including well number, date, and gas concentration, are presented in Table 4-1. During the January and March 2006 monitoring events, methane was only detected at monitoring point LG-10 (Figure 4-2), at concentrations of 3.0% and 0.5% by volume, respectively. These concentrations equal 61% and 10% of the LEL, respectively. Landfill gas monitoring point LG10 has typically had elevated concentrations of methane gas that have exceeded 25% of the lower explosive limit. In the vicinity of LG10 is an oil/water separator (OWS) and holding tank that was associated with a former vehicle wash area.

This OWS has been evaluated under the Wastewater Program of Environmental Management and is in good physical condition, and not considered a source of the methane. Methane was not detected at the Building 878 locations. The OU4 soil gas monitoring field logs are presented in Appendix E on the enclosed Field Forms CD.

4.3 Conclusions

The change in the methane level in point LG10 from January to April 2006 (3.0% to 0.5%, respectively) is a significant reduction. OU4 landfill gas monitoring points will continue to be monitored quarterly and the trend in LG10 evaluated.

5.0 OU2 Semiannual LTM Groundwater Sampling: Round 18

The objective of the semiannual LTM program for OU2 is to evaluate the effectiveness of in-situ biodegradation and natural attenuation processes on petroleum hydrocarbon contamination in soil and groundwater. All monitoring was completed in accordance with the selected remedy described in the *Record of Decision for Spill Sites 2, 3, and 10 (Operable Unit 2)* (WPAFB, 1997). This chapter presents the results of the April 2006 (Round 18) sampling event at OU2. Additional discussions on the sampling rationale and procedures are presented in Appendix A3.

5.1 Introduction

On May 5, 1997, the Baseline evaluation of subsurface hydrocarbon contamination at OU2 was initiated in accordance with the *Draft-Final, Site-Specific Work Plan Addendum No. 2* (IT, 1997a) to the *Final Site-Specific Work Plan For Remedial Design Tasks under the BMP* (IT, 1995b). Field activities for the Baseline event included one round of soil gas and groundwater sampling to provide a reference distribution of petroleum hydrocarbons in the area. Results were reported in the *Final OU2 Baseline Sampling Results Report, Basewide Monitoring Program* (IT, 1999e). The subsequent LTM semiannual sampling rounds were conducted as follows:

- Round 1 conducted October 20 through October 23, 1997 (IT, 1997b)
- Round 2 conducted April 28 and 29, 1998 (IT, 1997c and 1998)
- Round 3 conducted October 15 and 16, 1998 (IT, 1999f)
- Round 4 conducted April 13 and 14, 1999 (IT, 2000b)
- Round 5 conducted October 11, 1999 (IT, 2000c)
- Round 6 conducted April 19, 20, 24 and 25, 2000 (IT, 2001a)
- Round 7 conducted October 17 and 19, 2000 (IT, 2001b)
- Round 8 conducted April 16 through April 19, 2001 (IT, 2002b)
- Round 9 conducted October 10, 11, 15 and 17, 2001 (IT, 2002c)
- Round 10 conducted April 16 through 18, 2002 (IT, 2003a)
- Round 11 conducted October 9 and 10, 2002 (IT, 2003b)
- Round 12 conducted April 9, 16, 17, 22, and 23, 2003 (Shaw, 2004a)
- Round 13 conducted October 2, 2003 (Shaw, 2004b).
- Round 14 conducted April 15 and 16, 2004 (Shaw, 2004c)
- Round 15 conducted October 7, 2004 (Shaw, 2005a)
- Round 16 conducted April 5 and 27, 2005 (Shaw, 2005b)
- Round 17 conducted October 17 and 18, 2005 (Shaw, 2006a)

5.2 Groundwater Sampling

During the April 2006 sampling event (Round 18) groundwater samples were collected from eleven of the twelve monitoring wells that comprise the current OU2 groundwater quality monitoring network in the vicinity of the petroleum, oil and lubricant (POL) tank farm. The OU2 ROD monitoring well network was selected by evaluating groundwater analytical data from the Baseline event and subsequent investigations. The majority of wells selected for sampling are located in the total volatile hydrocarbon (TVH) plume identified in the OU2 Feasibility Study (FS), *Final Feasibility Study for Spill Sites 2, 3, and 10 Within Operable Unit 2* (ES, 1996), and are screened across the water table which historically is the zone of highest concentration of dissolved phase hydrocarbons. The following wells represent the current ROD monitoring well network:

- 04-016-M
- P18-1
- P18-2
- OW-1
- OW-2
- OW-3
- OW-4
- NEA-MW20-2S
- NEA-MW21-3S
- NEA-MW26-3S
- NEA-MW28-5S

Monitoring well NEA-MW21-3S has historically had a hydrocarbon layer of varying thickness (up to 1 foot) present on the water surface. A free-product removal system was installed in NEA-MW21-3S during October 2002. The recovery system operated only sporadically since installation and has been disconnected. Ongoing groundwater sampling and free-product monitoring of NEA-MW21-3S is being conducted under the LTM program. Additional discussion regarding free product removal is presented in Appendix A3.

The following downgradient or sidegradient wells (Figure 5-1) that were sampled periodically:

- NEA-MW20-1D
- NEA-MW21-2D
- NEA-MW22-3S
- NEA-MW23-2S
- NEA-MW24-2S
- NEA-MW25-1D
- NEA-MW25-2I
- NEA-MW25-3S
- MW11-1
- OW-6
- 04-606-M

Monitoring well MW11-1 was sampled for the April 2006 sampling event. Current and historical field parameters and analytical data for the ROD and periodic monitoring wells are presented on Tables 5-1 and 5-2, respectively. The following sections discuss the OU2 ROD field sampling procedures and analytical data.

5.2.1 Groundwater Sampling Field Procedures

OU2 monitoring wells were purged and sampled using the low flow rate/low volume purging and sampling method (micropurge). Monitoring wells were purged and sampled with dedicated pneumatic bladder pumps in accordance with addendum to WPAFB FP 5-6. Micropurging procedures are presented in Appendix A3. Field measurements were recorded on groundwater purge logs (Appendix F1) and are summarized in Table 5-1.

5.3 Groundwater Analytical Parameters

Groundwater samples were sent to Severn Trent Laboratories (STL) in North Canton, OH, and analyzed for VOCs using U.S. Environmental Protection Agency (USEPA) Method 8260B, nitrate and sulfate using Method 300.0A, and methane, ethane, and ethene using Method SOP-RSK175. Request for Analysis/CofC records for the April 2006 OU2 ROD sampling event are presented in Appendix F2.

5.4 Soil Gas Sampling Field Procedures

The purpose of the soil gas probe monitoring at OU2 is to establish a correlation between levels of benzene, toluene, ethylbenzene, and total xylenes (BTEX) and TVH in the soil vapor and areas of known soil contamination. During the Baseline field activities, fifteen permanent soil gas probes were installed throughout the POL tank farm and downgradient vicinity to monitor for hydrocarbon vapor in the vadose zone above the water table. Construction details of the soil gas probes are presented in the *OU2 Baseline Sampling Results Report* (IT, 1999e). During construction activities at the POL tank farm in 2000 and 2001, soil vapor monitoring points OU2-SV04 and OU2-SV05 were destroyed. Monitoring point OU2-SV04 was covered by asphalt and sealed from the surface; monitoring point OU2-SV05 was destroyed and buried during construction of a new fueling station. Soil sample results, collected from the borings during the installation of these two soil vapor monitoring points, did not correlate well with subsequent soil vapor concentrations from these points collected during the Baseline event. Also, the correlation between soil vapor VOC concentrations and groundwater VOC concentrations has been inconclusive. For these reasons, soil vapor points OU2-SV04 and OU2-SV05 have not been replaced.

Round 18 soil gas samples were collected on April 17 and 19, 2006, from the thirteen operable soil gas probes. Soil gas samples were sent to STL, Los Angeles, CA, and analyzed for BTEX and total petroleum compounds (as gasoline and JP-4) by USEPA Method EPA-19 TO-3. Soil

gas samples were also analyzed for fixed gases (oxygen, carbon dioxide and methane) by American Society for Testing and Materials (ASTM) Standard Method D1946.

5.5 Analytical Results

The OU2 analytical results for the OU2 Round 18 sampling event are summarized in the following sections. A complete listing of all detected groundwater and soil gas parameters for Round 18 are presented in Appendix G. Full analytical data reports are contained on the enclosed Analytical Data CD.

5.5.1 Groundwater

Groundwater analytical results from Round 18, prior LTM sampling rounds, and historical OU2 sampling events are summarized in Table 5-2. Benzene and BTEX concentrations in groundwater, with the associated plumes, are presented on Figures 5-1 and 5-2, respectively. As seen in the figures, the benzene and BTEX plumes are centered immediately downgradient of the fuel storage tanks. However, only wells NEA-MW20-2S, NEA-MW-21-3S, and P18-2 had benzene and/or BTEX compounds detected. Groundwater analytical results from the Round 18 sampling are presented in Appendix G1 in a "detects only" format.

Natural Attenuation Parameters

Concentrations of the natural attenuation parameters of dissolved oxygen (DO), oxidation reduction potential (ORP) and ferrous iron were measured in the field and recorded on purge logs. These parameters are presented in Table 5-1. The distributions of the Round 18 DO, ORP, and ferrous iron concentrations in groundwater are presented on Figures 5-3, 5-4, and 5-5, respectively. Analytical results for sulfate and nitrate are presented in Table 5-2. The distributions of sulfate and nitrate concentrations in groundwater are presented in Figures 5-6 and 5-7, respectively.

Petroleum Hydrocarbon Compounds

Benzene concentrations ranged from below detection limits in the majority of the OU2 monitoring wells to a maximum of 9.1 µg/L in well NEA-MW20-2S. As seen in Figures 5-1 and 5-2, the current benzene and BTEX plumes, respectively, are compared to the 1991 – 1992 concentration contours from the *Installation Restoration Program Final Remedial Investigation (RI) Report for Operable Unit 2* (ES, 1995). The current plumes are centered at the south end of the POL tank and are collectively known as the POL tank farm plume.

5.5.2 Soil Gas

Soil gas analytical results are summarized in Table 5-3. Laboratory analytical data for soil gas are presented in Appendix G2 in a "detects only" format. Figure 5-8 compares the distribution of BTEX concentrations in the soil gas for Round 18 with the 1997 Baseline concentrations. As presented in Figure 5-9 the Round 18 TVH soil gas plume has a similar distribution to the BTEX presented in Figure 5-8. TVH is reported as the sum of gasoline and JP-4. Gasoline and JP-4 are comprised of a mixture of hundreds of hydrocarbon compounds, including BTEX. The highest hydrocarbon concentrations are centered immediately west of the POL tanks in the vicinity of SV06, SV08, SV10 and SV14 (Figures 5-8 and 5-9). A 12-inch fuel line runs adjacent to soil vapor points OU2-SV06 and –SV14, and near point –SV10 (Figures 5-8 and 5-9). These monitoring locations have historically had the highest concentrations of BTEX and total hydrocarbons (Table 5-3). Soil vapor will continue to be sampled at all vapor probe locations in future OU2 monitoring events.

5.6 Analytical Discussion

A discussion of analytical results at OU2 follows.

Groundwater

BTEX concentrations for the selected LTM monitoring wells are graphed as a function of time in Figures 5-10 through 5-21. Several figures present two graphs of BTEX concentrations for a single well. The top graph is at a scale that displays all the concentrations of BTEX; the bottom graph presents the data at a larger scale to distinguish the fluctuations of the lower concentrations.

Figure 5-22 presents a graph showing the benzene concentrations along the length of the hydrocarbon plume in the downgradient direction during selected previous LTM sampling events. The graph shows the highest benzene concentration at each location for several previous sampling events and for the current round.

The graph begins at a reference point of 0 feet, located at monitoring well 04-517-M which is immediately up gradient of the POL tank farm plume. Benzene concentrations at this well were below the detection limit and are considered 0 (zero) µg/L for the Baseline sampling (May 1997). This is the reference point for downgradient distances and concentrations for the Baseline and Rounds 1 through 18 sampling events. The distances between each well in the hydrocarbon plume, downgradient of well 04-517-M, are as follows:

- 04-517-M = 0 feet
- NEA-MW20-2S = 420 feet
- NEA-MW21-3S = 860 feet
- 04-518-M = 930 feet (abandoned)
- OW-1 = 1130 feet
- NEA-MW28-5S = 1310 feet
- OW-3 = 1480 feet
- P18-2 = 1580 feet
- OW-4 = 1660 feet
- P18-1 = 1855 feet.

Monitoring well OW-6 (2,100 feet downgradient) is sampled periodically and did not have benzene detected in any of the three rounds it was sampled (May 1997, April 2000, October 2002). In general, Round 18 groundwater concentrations of benzene and BTEX have shown significant decreases in the vicinity of Spill Site 10 (SP10) (Figures 5-1 and 5-2) since the OU2 RI sampling (ES, 1995). Figure 5-20 illustrates the benzene reduction in well P18-1. In the POL tank farm plume, benzene and BTEX concentrations have decreased compared to those reported in the Baseline sampling and the center of the plume has shifted slightly to the southwest.

Natural Attenuation Parameters

The expected relationship between BTEX concentrations and the concentration of a particular natural attenuation parameter (electron acceptor or its reduction product), when natural attenuation is occurring, is summarized in the following table from *Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites* (ASTM E 1943, April 1998):

BTEX	Oxygen	Ferrous Iron	Sulfate	Nitrate	Manganese	Methane
High	Low	High	Low	Low	High	High
Low	High	Low	High	High	Low	Low

When comparing the BTEX concentrations in groundwater (Figure 5-2) to the concentrations of the natural attenuation parameters of DO (Figure 5-3), ferrous iron (Figure 5-5), sulfate (Figure 5-6), and nitrate (Figure 5-7), a correlation similar to the above table is not always present for every parameter. ORP concentrations are presented in Figure 5-4. The ORP of groundwater is a measure of the relative tendency of a solution to accept or donate electrons. Comparing upgradient and high levels of ORP to the lower ORP levels within the plume indicate zones where biodegradation (especially anaerobic processes) is occurring (ASTM, 1998).

Table 5-4 compares the highest detected benzene concentrations from previous sampling events at selected wells with concentrations from the last round of sampling. Benzene concentrations in the SP10 plume area have substantially decreased from the initial concentrations. Figures 5-10 through 5-21 present the concentrations of BTEX compounds through time for the current OU2 ROD wells.

The 1992 model of the POL tank farm area (ES, 1996) predicted that benzene concentrations would be below the MCL in 8-9.5 years (2000-2002). This was a conceptual model, which idealized conditions and estimated future contaminant concentrations in soil or groundwater. After 12 years (1993-2005), not all areas are below the MCL; however, there has been a significant decrease in benzene concentrations. As an example, benzene concentrations at well P18-1 have decreased from a high of 570 µg/L in August 1991 to below the detection limit during the April 2006 sampling event. Currently, only the area immediately downgradient of the POL tanks still exceeds the benzene MCL (Figure 5-1). LTM results to date indicate that BTEX concentrations are generally being lowered towards remediation goals.

Soil Gas

BTEX and TVH concentrations for the soil gas LTM monitoring points are graphed as a function of time in Figures 5-23 through 5-35. Soil gas analytical results from the Round 18 sampling event indicate lower concentrations of BTEX and TVH compounds when compared to previous sampling periods.

5.7 Groundwater Flow

Figure 5-36 presents a graph of the average water level elevations for the Baseline and the 18 subsequent LTM sampling events at OU2. An average ground surface elevation for the site has been provided for a reference on depth to the water table. The water table is typically higher in the spring of the year (April events). BTEX concentrations at well 04-518-M (Figure 5-11) had exhibited a correlation with seasonal fluctuations in groundwater elevation. Comparison of TVH and BTEX concentrations to groundwater elevation variations does not suggest a strong correlation to seasonal high water tables.

Figure 5-37 illustrates the groundwater flow pattern through OU2 during the April 2006 sampling event. Depth to water measurements and water level elevations are presented in Table 5-5. Groundwater is flowing predominantly from northeast to southwest through OU2. The water level field log is located in Appendix F3.

5.8 Evaluation of Free-Product Removal

A large-scale recovery system was installed during the September-October 2002 sampling event and activated in November 2002 to replace the passive system previously in place. A complete discussion on the passive free product recovery that was used at well NEA-MW21-3S is presented in Appendix A3. The remediation system, called a "Bioslurper," is a flexible vacuum tube that is installed inside a monitoring well and used to vacuum the light, non-aqueous phase liquid hydrocarbons (LNAPL) from the surface of the water table. Due to mineral fouling and intermittent free product recovery, the system had not operated continuously since installation and has been deactivated. When the Bioslurper was in operation contaminated groundwater, along with minor LNAPL, was processed through the Bioslurper system's phase separation tank, oil-water separator, and liquid and air carbon units. The finished water was then discharged via the storm sewer under a National Pollutant Discharge Elimination System (NPDES) discharge permit.

5.9 Conclusions

Figures 5-1 and 5-2 provide a comparison of the current benzene and BTEX concentrations in groundwater to the RI results from 1991 and 1992 (ES, 1995). Comparing the Round 18 benzene and BTEX isopleths to the RI isopleths plotted on the figures, indicate that the extent of benzene and BTEX plumes at SP10 have significantly decreased since 1991-1992. The centers of the benzene and BTEX plumes in the POL tank farm have shifted slightly to the southeast and the concentrations have decreased since RI sampling.

Based on the interpreted groundwater flow vectors shown on Figure 5-37, monitoring wells NEA-MW25-3S, NEA-MW25-2I, NEA-MW25-1D, OW-6, and NEA-MW26-3S provide good downgradient definition of the OU2 hydrocarbon plumes at various depths. During the OU2 Baseline monitoring event in May 1997, all shallow depth monitoring wells in the vicinity of OU2, including downgradient wells OW-6 and NEA-MW25-3S, were sampled (IT, 1999e). Many of the monitoring wells in this area have remained in the OU2 monitoring program; however, the number of wells and the frequency of downgradient monitoring have been modified from the Baseline network. In addition to the semi-annual sampling of the thirteen OU2 ROD wells, WPAFB periodically monitors downgradient wells that may be identified as potential down- or side-gradient contaminant migration monitoring points, to monitor for any unforeseen migration. Selection of these wells has varied from year to year.

In the April 2005 LTM report (Shaw, 2006) WPAFB proposed that selected wells that had been sampled semiannually and periodically be deleted from the LTM program at OU2 due to the reduction in the hydrocarbon plume to within the POL boundaries. The following wells were recommended for deletion from the OU2 LTM program:

- OW-3
- OW-4
- OW-6
- P18-1
- P18-2
- NEA-MW24-2S
- NEA-MW25 (All)
- NEA-MW26-3S
- NEA-MW28-5S
- MW11-1

Monitoring wells OW-1 and OW-2 were kept as a downgradiant control points for the POL plume.

In USEPA's comments on the Draft April 2005 LTM report dated December 22, 2005 and in OEPA's approval letter for the draft report dated January 20, 2006, it was agreed that these wells were not necessary for the continued monitoring of natural attenuation of the groundwater plumes at OU2. However, USEPA specified that if future sampling results indicate an increase in the hydrocarbon constituent concentrations at the new downgradient wells (e.g., OW-1 and OW-2) or an increase in the size of the groundwater plumes, then these wells should be re-activated into the monitoring program as necessary.

The following wells will be retained in the OU2 monitoring well network:

- 04-016-M
- 04-606-M
- OW-1
- OW-2
- NEA-MW20-2S
- NEA-MW21-3S
- NEA-MW22-3S
- NEA-MW23-2S

This well network will be sampled in it's entirety during the October 2006 LTM sampling event. The following wells will be sampled periodically beginning with the April 2007 monitoring event:

- NEA-MW20-1D
- NEA-MW21-2D.

6.0 Basewide Long-Term Groundwater Monitoring

Chapter 6 presents the results of the GWOU long-term groundwater monitoring at WPAFB, Ohio. Data evaluation and conclusions are discussed in Chapter 7. Discussions on LTM site history, sampling rationale, and monitoring procedures are presented in Appendices A2 and A4.

6.1 Introduction

The April 2006 Basewide LTM event consisted of the semiannual sampling of Basewide groundwater monitoring wells for VOCs, annual sampling for VOCs, and annual sampling for inorganic contaminants (metals). Source areas monitored semiannually for VOCs include the vicinity of former Building 59, the former Building 79/95 Complex, Burial Site 5 (BS5), and Operable Units 2, 3, 4, 5 (FAA-A), 8 and 10. Annual VOCs sampling was conducted at BS6, FAA-B (SP11), OU8, and OU9. Annual metals sampling was conducted at Operable Units 2, 3, 5, 8, 9, and 10. Sampling frequencies for selected Basewide monitoring wells are specified in Table A1-1 (Appendix A1). Further information on the LTM program, including objectives, have been presented in the October 1998 Final LTM Report (IT, 1999a).

6.2 Site Location and Description

A summary of the source operable units included within the GWOU is provided in Appendix A of the EE/CA (IT, 1999b). Operable Units 2, 3, 4, 5, 7 and 10 are located within Areas A & C of WPAFB (Figure 1-3). Operable Units 1, 6, 8, and 9, FAA-B, former Building 59, former Building 79/95 Complex, and BS5 and BS6 are all located within Area B (Figure 1-4). A brief description of each OU is also provided in the October 1998 Final LTM Report (IT, 1999a).

As discussed in Chapter 1, the GWOU was established under the BMP to provide a comprehensive method for monitoring and evaluating the individual source areas (OUs), any plume migration, and the natural attenuation of contaminants. Further discussion of the BMP is provided in the October 1998 LTM report (IT, 1999a). Specific objectives of the BMP are presented in the *Site-Specific BMP Work Plan* (IT, 1995b).

This section describes the LTM activities associated with all wells in the LTM network, with the exception of wells specified in the OU1 and OU2 RODs. LTM activities at OU1 and OU2 are discussed in Chapters 2 and 5, respectively.

6.3 Basewide LTM Groundwater Sampling

Monitoring wells for the Basewide LTM program were purged and sampled using the micropurge low flow-rate technique in accordance with the addendum to FP 5-6. Monitoring wells were purged and sampled with dedicated submersible bladder (pneumatic) or low flow electric (Grundfos®) pumps (GR-333 and GR-334). The dedicated bladder pumps were either existing in the wells from sampling programs prior to the Baseline event or were installed during the subsequent investigations or monitoring programs listed below:

- BMP Baseline (April 1998)
- BMP October 1998
- Building 59 Site Investigation (1998)
- FAA-B / Spill Site 11 (1995 and 1999)
- Building 79/95 Complex Site Investigation (2002)

Electrical submersible pumps were installed during prior investigations at OU10. Table A1-2 (Appendix A1) presents a summary of the Basewide LTM Program well inventory.

6.3.1 Well Purging

Monitoring wells were purged in accordance with procedures summarized in Appendix A2. Purge logs for sample collection are presented in Appendix H; field parameters were measured just prior to sampling and are summarized in Table 6-1.

Purge water was containerized, transported back to a central staging area, and disposed at a permitted treatment and disposal facility. The Bill of Lading for purge water disposal is also included in Appendix H.

6.3.2 Monitoring Well Locations

Under the Basewide LTM program, groundwater samples were to be collected from 55 monitoring wells for semiannual VOC analysis, 14 monitoring wells for annual VOC analysis, and 13 monitoring wells for annual metals analysis. Groundwater sampling was conducted from April 4 through April 20, 2006. Of the original semiannual VOCs monitoring well network presented in the EE/CA (IT, 1999a), well LF12:MW15A was damaged during tree removal activities during the summer of 2003 and was not replaced. In addition, for the April 2002 sampling event semiannual VOCs monitoring well OU4-MW-04A [screened interval: 9.5-19.5 ft below ground surface (bgs)] was replaced in the network by well OU4-MW-04B (screened interval: 30.5 to

40.5 ft bgs), a deeper well screened in the zone of contamination detected upgradient. In 2004 annual metals monitoring wells 14-554-M, NEA-MW01-1S, NEA-MW02-2S, P4-2 (EFDZ10-MW02) and EFDZ8-MW01 were evaluated using geochemical statistics (Shaw, 2004a) and were identified as all detected metals were naturally occurring. These wells were abandoned during April 4 through April 6, 2005.

Monitoring well locations and the April 2006 analytical results are presented by management area on Figures 6-1 through 6-18. Sampling frequencies for selected Basewide monitoring wells are specified in Table A1-1 (Appendix A1). This table contains the monitoring frequency, sampling months, analytical parameters, and other sampling rationale for all groundwater sampling locations monitored under the LTM program. This is a dynamic table that may contain small variations in the LTM network between sampling events. These variations (typically additions) to the LTM network are the result of data evaluations from previous rounds and incorporation of monitoring wells from completed projects (i.e., Building 59 Site Investigation). The current monitoring well networks that comprise the LTM program for each area of concern are presented in Appendix A4.

6.3.3 Sample Management

Throughout the LTM program, each sample has been designated with a unique sample number that identifies the location, type of sample collected, and sampling event date. ShawView (sample tracking database by Shaw Environmental, Inc.) was used for the first time during the October 2002 sampling event. The new ShawView sample numbering system has been incorporated with all recent sampling events since its institution. An explanation of the sample numbering system is presented in Appendix A2.

6.3.4 Sample Handling

CofC records were completed for each sample. CofC records contain sample numbers, date and time of collection, sample names, container types and volumes, preservatives, and analytical parameters. CofC records for the April 2006 Basewide LTM sampling event are presented in Appendix I. Sample handling procedures are presented in Appendix A2.

6.3.5 Project Generated Wastes

Wastewater generated during the field sampling activities consisted of monitoring well purge water. Wastewater was pumped into 55-gallon drums on each field vehicle then transported into

the contractor parking lot near OU4 for transfer into a 550-gallon storage tank. Approximately 550 gallons of wastewater were generated during the April 2006 LTM field activities. The wastewater was transported by vacuum tank-truck to a permitted treatment and disposal facility (Perma-Fix of Dayton). The WPAFB LTM purge water shipping document is included in Appendix H. Purge waters are being shipped under a waste profile previously defined for this waste stream.

6.3.6 Procedure Variances

The only variance to the task Statement of Work was the use of the existing dedicated Grundfos® electric submersible pumps in wells GR-333 and GR-334. Electric submersibles were used instead of installing new bladder pumps. The pumps and fixtures in these wells appeared to be permanently attached and were left in-place for purging and sampling in accordance with FP 5-6 for electric submersible pumps (ES, 1990; FP 5-6 Addendum, 1998).

6.4 Analytical Results

Analytical results by parameter group are discussed in the following sections.

6.4.1 VOCs

The VOC analytical results from the April 2006 Basewide LTM sampling are presented in Table 6-2 by area, along with historical groundwater analytical data for each well. Figures 6-1 through 6-12 present the detected concentrations of VOCs for each management area (concentrations exceeding MCLs are denoted in red). The April 2006 laboratory data for VOCs analysis are presented in Appendix J in "detects only" format. Full analytical reports are provided on the enclosed Analytical Data CD.

As defined in the EE/CA, the remediation goal for organic COCs [benzene; ethylbenzene; xylenes; toluene; 1,2-dichloroethane (1,2-DCA); total 1,2-dichloroethene (1,2-DCE); TCE; vinyl chloride; and tetrachloroethene (PCE)] is the MCL for each constituent. Detected concentrations exceeding the MCLs in Table 6-2 are denoted with "( )." The maximum concentration of TCE (180 µg/L) and total 1,2-DCE (220 µg/L) detected during the April 2006 sampling event occurred at former Building 59 in well B59-MW03 (Figure 6-1). The maximum concentration of vinyl chloride (120 µg/L) was detected at FAA-B in well SP11-MW03 (Figure 6-10). PCE was detected in well BS5 P-4 at a maximum detected concentration of 20 µg/L at Burial Site 5 (Figure 6-3).

6.4.2 Metals

The April 2006 Basewide LTM sampling analytical results for dissolved metals are presented in Table 6-3. Total metals analytical results for each management area are presented in Tables 6-4 through 6-7 along with historical groundwater analytical data for each well. Table 6-8 presents a summary of the April 2006 total metals analytical data. Figures 6-13 through 6-18 present the detected concentrations for metals of concern by management area. The April 2006 laboratory data for metals analysis are presented in Appendix K in "detects only" format. Full analytical reports, including case narratives, are provided on the enclosed Analytical Data CD.

As defined in the EE/CA (IT, 1999b); remediation goals (RGs) for metals of concern were determined by the aquifer layer and aquifer material characteristics. Concentrations of total and dissolved metals of concern that exceed the RG and/or MCL are denoted with "( )" in the tables and are red in the figures. During the April 2006 event, dissolved metals concentrations exceeding RGs and/or MCLs were detected in areas OU3, OU5 and OU9 (Table 6-3). Total metals concentrations exceeding RGs and/or MCLs were detected in areas OU2, OU5 and OU9 (Table 6-8).

6.5 Data Evaluation

The following sections discuss the analytical results from the Basewide LTM sampling for each area. For wells that have a history of VOCs above MCLs, a brief discussion of the historic concentrations trend is also presented. More comprehensive data evaluations and conclusions are discussed in Chapter 7. Table 6-2 presents a summary of the current Basewide LTM and historic groundwater VOC analytical data. Figures 6-19 through 6-58 present graphs of the historical groundwater VOC analytical data collected through April 2006 for wells where chemicals of primary concern have a history of exceeding MCLs. In the legend of each graph, the MCL concentration is noted for the VOCs of concern detected at that well location. A summary of the historic groundwater sampling results for the VOC contaminants of concern for the OU5 monitoring well network is presented in Table A4-1 (Appendix A4).

Dissolved and total metals concentrations for the April 2006 Basewide LTM sampling event are presented in Tables 6-3 and 6-8, respectively. The following discussion provides a general evaluation of the VOC contaminant trends and the detected metals for each management area.

Former Building 59

To monitor the VOC concentrations in groundwater at the former Building 59 site, four monitoring wells were added to the semiannual sampling program in April 2001 (Figure 6-1). For more information on the former Building 59 site, see Appendix A4.

Figures 6-19 through 6-21 present graphs of the current and historic VOC concentrations at former Building 59. In June 2005 a solution of sodium permanganate was injected into B59-MW02 to test the viability of oxidizing TCE in the area of MW-02 and MW-03. Well B59-MW02 was not sampled in October 2005. During the April 2006 sampling event, well B59-MW03 (Figure 6-21) had elevated concentrations of TCE (180 µg/L), total 1,2-DCE (230 µg/L) and vinyl chloride (37 µg/L). Monitoring wells B55-MW02 and –MW03 are completed entirely into the limestone bedrock to depths of 31 and 20 feet, bgs, respectively.

Well B59-MW04 historically has had intermittent detections of vinyl chloride above the MCL (Table 6-2). However, during April 2006 vinyl chloride was detected at an estimated concentration of 1.2 µg/L, which is below the MCL. VOCs were not detected in well B59-MW01 during the sampling event. Monitoring well B55-MW01 overlaps the soil bedrock interface with 5.5 feet of screen in the unconsolidated overburden and 4.5 feet of screen in the weathered limestone bedrock. Well B55–MW04 is screened six feet in the overburden and four feet into weathered bedrock. Wells B55-MW01 and -MW04 are completed to depths of 15.5 and 17.5 feet, bgs, respectively.

Former Building 79/95 Complex

To monitor the VOC concentrations in groundwater at the former Building 79/95 complex, four monitoring wells were added to the semiannual sampling program in October 2002 (Figure 6-2). These four wells were installed and sampled in February 2002 as part of the Building 79/95 Complex SI (IT, 2003d). TCE was detected in all four wells during the SI sampling (Figures 6-22 and 6-23). For more information on the Building 79/95 Complex SI, see Appendix A4.

During the April 2006 sampling event, TCE was detected in all four wells at concentrations that exceed the MCL (5 µg/L) (Table 6-2). The current TCE concentrations range from 19 µg/L (B79C/D-MW03) to 50 µg/L (B79C/D-MW04). Total 1,2-DCE has been detected in wells -MW01, -MW03 and -MW04, at concentrations below the MCL (70 µg/L).

BS5

As seen in Figure 6-3, groundwater monitoring at BS5 is completed at two areas. The monitoring well pair BS5 P-1 and P-2 bracket an area close to the museum runway. As seen in Table 6-2, TCE and PCE concentrations in this area have historically been below MCLs (5 µg/L) at well BS5 P-1 and not detected at BS5 P-2. The April 2006 results are consistent with the historical data.

The second groundwater monitoring area is at the BS5 P-3 and P-4 well cluster located due south of BS5 P-2, near the Base boundary. Historically, TCE concentrations in this area have remained below the MCL, while PCE concentrations have been above the MCL at concentrations ranging from 16 µg/L to 33 µg/L (Table 6-2). During the April 2006 sampling round, PCE was detected at 20 µg/L in both BS5 P-3 and P-4 and remain consistent with previous sampling events. Data trends for the two monitored areas in BS5 are presented on Figures 6-24 and 6-25.

BS6

VOCs were not detected at wells BS6 P-1 and BS6 P-2 during the April 2006 annual sampling round (Table 6-2). Historically, BTEX compounds have been detected at BS6 P-2, but always below the MCLs in the most recent events (Figure 6-26).

OU2

As seen in Figure 6-4, PCE was detected slightly above the MCL (5 µg/L) in well NEA-MW27-3I (6.7 µg/L) during the April 2006 event. PCE concentrations have decreased since the April 2000 sampling event (23 µg/L), but have stabilized at between 5.5 and 7.5 µg/L over the last six sampling events (Figure 6-27). VOCs have not been detected in well NEA-MW34-2S since TCE was detected at a concentration of 15 µg/L, in December 1992 (Figure 6-27).

As seen in Table 6-4, the Layer 1 "Outwash" aquifer RG for total chromium (100 µg/L) was exceeded at well NEA-MW24-2S (550 µg/L). All other detected metals concentrations were below their respective RGs. OU2 metals monitoring wells 14-554-M, NEA-MW01-1S, and NEA-MW02-2S were removed from the LTM program and abandoned in early April 2005. The historic metals detections in these wells were evaluated prior to abandonment using a geochemical statistics model (Shaw, 2004b). It has been shown that the detections of what were the metals of concern were naturally occurring and were not from a Base source.

OU3

For the April 2006 sampling event, all detected VOCs were below MCLs (Figure 6-5). The upper riser casing of well LF12:MW15A was damaged beyond repair and was subsequently abandoned in November 2003. Historically, both TCE and total 1,2-DCE have been detected at low concentrations in wells LF12:MW15A, 05-DM-123S-M, and 05-DM-123I-M (Figures 6-28 through 6-30). Concentrations of TCE in these wells have typically been between 2 and 2.5 µg/L.

Under the LTM program, metals analyses are conducted at one OU3 well, 07-520-M. During the April 2006 sampling event, thallium (12 µg/L) was the only inorganic of concern detected above the associated RG (2 µg/L) (Figure 6-14).

OU4

During the April 2006 sampling event, TCE was detected above the MCL (5 µg/L) at only one of the eight monitoring locations (Figure 6-6). Well OU4-MW-02B had a detected concentration of 8.1 µg/L. TCE was detected at concentrations below the MCL in wells BMP-OU4-1B-60, OU4-MW-03B, -03C, and -12B (Table 6-2). Historically, wells -MW-02B, -MW-03B, -MW-03C, and -MW-12B, have consistently had TCE concentrations detected above or near the MCL since the RI sampling. As seen in Figures 6-32 through 6-34, the highest concentrations of TCE were detected in 1993 in all four wells.

PCE was detected above the MCL (5 µg/L) at well -MW-12B (12 µg/L) during the April 2006 event (Table 6-2). PCE was detected at a concentration below the MCL in well OU4-MW-03C (Table 6-2).

Since 1998, total 1,2-DCE has been detected at varying concentrations below the MCL (70 µg/L) in all the OU4 wells monitored except well OU4-MW-04B. The highest detected historical concentration of total 1,2-DCE (9.7 µg/L) occurred in well -MW-02A in October 1999 (Table 6-2) and the April 2006 concentration is 4.1 µg/L (Figure 6-32).

OU5 (FAA-A)

As seen in Figure 6-7, TCE concentrations exceeded the MCL (5 µg/L) at wells CW05-085, CW10-055, HD-11, and MW132-S, during the April 2006 sampling event at concentrations ranging from 5.4 µg/L to 31 µg/L. Historically, OU5 wells, CW05-055, CW-05-085, and HD-11

have had the highest concentrations of TCE (Figures 6-37 through 6-39). Well MW132-S has had detections of TCE ranging from 20.6 µg/L to 40 µg/L since 1992 (Figure 6-43).

During the April 2006 sampling event, PCE was detected below the MCL (5 µg/L) at wells HD-12S, MW131S and MW132S (Figure 6-7). Historically, PCE has usually been detected at downgradient wells MW131-S, MW132-S, and HD-12S since at least 1993 (Table 6-2) and has never been detected at any of the remaining ten wells.

To date, total 1,2-DCE has been detected at concentrations below the MCL (70 µg/L) in ten wells (Table 6-2). The last time the total 1,2-DCE concentrations exceeded the MCL was in 1994, at well MW131M at a concentration of 74 µg/L (Figure 6-42).

Vinyl chloride was detected at concentrations below the MCL (2 µg/L) in five wells. MW131M has historically had vinyl chloride concentrations exceeding the MCL since 1996, with the highest detection, 22 µg/L, occurring in April 1999 (Table 6-2).

As seen in Tables 6-3 and 6-5, the Layer 2 "Outwash" aquifer RG for manganese (134 µg/L) was exceeded at well CW15-055 in the dissolved (510 µg/L) and total (470 µg/L) samples, respectively. No other inorganics of concern were detected above RGs at OU5.

An in-situ remediation technique consisting of injecting an oxidizing reagent into the subsurface was conducted during June and July 2000 at OU5. Additional information on this injection test is in Appendix A4. Trends on current VOC concentrations are discussed in Section 7.0.

OU8

VOCs were detected only in well CW03-77 of the four monitoring locations sampled during the April 2005 event. The detections were at concentrations below the reporting limit (Figure 6-8). VOCs have not been detected in well CW03-77 above the MCL since TCE was detected at a concentration of 7.4 µg/L in 1994 (Table 6-2).

Under the LTM program, metals analyses are conducted at two OU8 wells, OU8-MW-02D and OU8-MW-23D. Detected inorganics of concern at OU8 were below the associated RGs (Tables 6-3 and 6-8).

OU9

All VOCs detected at OU9 were below the MCLs (Figure 6-9) for the April 2006 sampling event. Historically at well EFDZ4-MW06, 1,2-DCA has been detected intermittently at concentrations above the MCL (5 µg/L) since 1994 (Figure 6-46).

Two OU9 wells were sampled for metals analysis during the April 2006 sampling event (Figure 6-17). Wells EFDZ8-MW01 and P4-2 (EFDZ10-MW02) were evaluated using a geochemical statistics model (Shaw, 2004b). It has been shown that the detections of what were the metals of concern were naturally occurring and were not from a Base source. These two wells were subsequently abandoned in April 2005.

During the April 2006 sampling event, nickel (160 µg/L) was detected at a concentration above the RG (119 µg/L) in well EFDZ3-MW02 (Table 6-3). Thallium was detected above the RG (2 µg/L) at a concentration of 11 µg/L in both EFDZ3-MW02 and EFDZ3-MW03 (Table 6-3).

FAA-B (SP11)

As seen in Figure 6-10, VOCs were detected at six of the seven sampling locations during the April 2006 event. Vinyl chloride was detected above the MCL (2 µg/L) at four locations, with concentrations ranging from 5.3 µg/L (SP11-MW08) to 120 µg/L (SP11-MW03). Historically, vinyl chloride has consistently been detected above the MCL in wells SP11-MW01 and -MW03 since 1995, with the highest concentrations for both occurring during the April 2000 sampling event (Figures 6-47 and 6-48). Wells -MW07, -MW08 and -MW09 have also had consistent detections of vinyl chloride since they were installed in October 1999 (Figures 6-49 and 6-50).

TCE was detected above the MCL (5 µg/L) at two locations, SP11-MW03 and –MW09, at concentrations of 5.2 µg/L and 7.0 µg/L, respectively. Total 1,2-DCE was detected at six sampling locations, however, all concentrations were below the MCL (70 µg/L).

Between October 26 and October 29, 1999, an in situ treatability test was conducted at FAA-B to evaluate the effects of Fenton's Reagent on the VOC contamination in the subsurface soils and groundwater (IT, 2000d). Additional information on this injection test is in Appendix A4. Trends in the current VOC concentrations are discussed in Section 7.0.

OU10 (CHP4)

Table 6-2 and Figure 6-10 present the April 2006 detections for the three OU10 (CHP4) sampling locations. In addition, LTM graphs for these three wells are presented on Figures 6-51 and 6-52. During the April 2006 sampling event, the PCE MCL (5 µg/L) was exceeded at well GR-330, at a concentration of 18 µg/L. Figure 6-52 shows the historic trend for PCE concentrations in well GR-330. As seen in the figure, PCE concentrations have typically been above the MCL in well GR-330. All other VOCs detected were below the MCLs.

OU10

TCE was detected above the MCL (5 µg/L) at two of the eleven sampling locations during the April 2006 sampling event (Figure 6-12). Wells OU10-MW-06S and -MW-11D had TCE detections of 12 µg/L and 7.6 µg/L, respectively. Historically, wells -MW-06S and -MW-21S have had TCE detections consistently above or just below the MCL since at least 1995. TCE concentrations in well GR-333 have been below the MCL since October 1998. Figures 6-53 through 6-57 present the TCE concentration trends in the OU10 wells.

As seen in Table 6-2, the PCE concentration continue to exceed the MCL (5 µg/L) at well OU10-MW-11S (13 µg/L). Historically, PCE concentrations have exceeded the MCL consistently in this well since 1994. The PCE concentration in well OU10-MW-03S oscillates above and below the MCL depending on the season and was detected at a concentration of 5.6 µg/L during the current event. Figures 6-53 through 6-56, and Figure 6-58 present the PCE concentration trends in the OU10 wells.

All groundwater samples were analyzed for methyl tertiary-butyl ether (MTBE) for the first time in October 2000and have continued since. Since that time, the only MTBE detected has been in well NEA-MW37-1D at concentrations below 1 µg/L (Table 6-2).

Metals were analyzed at six OU10 wells (Figure 6-18). During the April 2006 sampling event, thallium was detected above the MCL (2 µg/L) and RG (2.6 µg/L) at a concentration of 12 µg/L in well OU10-MW10I (Table 6-8). All other detected total and dissolved metals concentrations were below the associated RGs and MCLs (Tables 6-3 and 6-8, respectively).

7.0 Basewide Groundwater Operable Unit Evaluation

This chapter presents an evaluation of the analytical results across each of the investigation areas that comprise the Basewide GWOU. This evaluation uses data from the April 2006 Basewide LTM sampling event. The current LTM results are compared to the concentration data collected during previous LTM events and the RI activities (IT, 1997d) to evaluate whether there exists:

- Discernable differences in the distribution of VOC detections
- Discernable differences in the distribution of VOC concentrations.

7.1 VOC Analytical Findings

Investigation areas where contaminants of concern were detected during the April 2006 LTM sampling event are identified below by contaminant for the following organic compounds: TCE; PCE; total 1,2-DCE; vinyl chloride; 1,2-DCA; benzene; toluene; ethylbenzene; xylene; and MTBE. Table 6-2 presents the current and historic groundwater concentrations for these compounds at each monitoring well sampled under the Basewide LTM program.

7.1.1 TCE

During the April 2006 event, TCE was detected in the following Basewide LTM investigation areas at concentrations that exceed the MCL (5 µg/L):

- Former Building 59 Complex (wells B59-MW03)
- Former Building 79 Complex (wells B79C/D-MW01, -MW02, -MW03, and -MW04)
- OU4 (well OU4-MW-02B)
- OU5 (wells CW05-085, CW10-55, HD-11 and MW132S)
- FAA-B/Spill Site 11 (well SP11-MW03 and –MW09)
- OU10 (wells OU10-MW06S and -MW11D).

TCE was also detected at concentrations below the MCL in additional wells located within the investigation areas identified above (Table 6-2). TCE was detected at concentrations below the MCL in areas OU3, OU8, OU9, and OU10/CHP4. TCE was not detected in the remaining investigation areas (BS5, BS6, and OU2). Over the last several years, TCE concentrations have been stable to generally decreasing across most of the Basewide investigation areas with the exception of the former Building 59 where TCE concentrations had been increasing in well B59-MW02. In June 2005, VOC contaminants in groundwater and the bedrock geologic formation surrounding well B59-MW02 were treated by oxidant injection (see Section 7.2.1).

Currently, the COC concentrations for this well (including TCE) are below detection levels (Table 6-2).

7.1.2 PCE

During the April 2006 event, PCE was detected in the following Basewide LTM investigation areas at concentrations that exceed the MCL (5 µg/L):

- Burial Site 5 (wells BS5 P-3 and BS5 P-4)
- OU2 (well NEA-MW27-3I)
- OU4 (well OU4-MW-12B)
- OU10/CHP4 (wells 23-578-M and GR-330)
- OU10 (wells OU10-MW-11S, and -MW-25S).

PCE was also detected at concentrations below the MCL in additional wells located within some of the investigation areas identified above. PCE was detected below the MCL at areas OU5, OU8, and OU9. PCE was not detected at the remaining investigation areas (former Building 59 and 79 Complexes, BS6, OU3, and FAA-B). In general, PCE concentrations have been consistent or slowly decreasing since the Baseline sampling event.

7.1.3 Total 1,2-DCE

During the April 2006 event, total 1,2-DCE was detected in the following Basewide LTM investigation area at concentrations that exceed the MCL (70 µg/L):

- Former Building 59 Complex (wells B59-MW02 and -MW03).

Total 1,2-DCE was also detected at concentrations below the MCL in an additional well located at the former Building 59 Complex, at OU5, and at FAA-B. In addition, total 1,2-DCE was detected at concentrations below 9.0 µg/L at the former Building 79, OU3, OU4, and OU9 areas. Total 1,2-DCE was not detected in samples from other areas of the Base (BS5, BS6, OU2, OU8, OU10/CHP4, and OU10). In general, total 1,2-DCE concentrations have been stable or slowly decreasing since the Baseline sampling event with the exception of Building 59 where the concentration of total 1,2-DCE in well B59-MW02 has increased to its highest level.

7.1.4 Vinyl Chloride

During the April 2006 event, vinyl chloride was detected in the following Basewide LTM investigation areas at concentrations that exceed the MCL (2 µg/L):

- Former Building 59 Complex (wells B59-MW02 and -MW03)
- OU5 (well MW131M)
- FAA-B/Spill Site 11 (wells SP11-MW01, -MW03, -MW07, and -MW08).

Vinyl chloride was also detected at concentrations below the MCL in additional wells located within the investigation areas identified above (Table 6-2). Vinyl chloride concentrations have remained consistent with historic levels or have fluctuated slightly at all of these investigation areas. Vinyl chloride was not detected in the remaining investigation areas of the Base (BS5, BS6, OU2, OU3, OU4, OU8, OU9, OU10/CHP4, and OU10).

7.1.5 1,2-DCA

During the April 20006 event, 1,2-DCA was not detected at concentrations that exceed the MCL (5 µg/L). 1,2-DCA was detected in only three Basewide monitoring areas (one well in each the former Building 59 Complex, OU5 and OU9 areas). The highest detected concentration of 1,2-DCA for the April 2006 monitoring event occurred in OU9 well EFDZ4-MW06 (2.9 µg/L). 1,2-DCA has either never been detected or has been sporadically detected at concentrations below the MCL in the remaining LTM wells.

7.1.6 Benzene, Toluene, Ethylbenzene, and Total Xylenes

During the April 2006 event, benzene and/or toluene were detected at trace concentrations below the MCLs (5 µg/L and 1,000 µg/L, respectively) at former Building 59, OU5, and FAA-B. Ethylbenzene and total xylenes were not detected during the April 2006 sampling event. Since the Baseline sampling, BTEX compounds have been sporadically detected at concentrations below their respective MCLs at most investigation areas. The exception is benzene, which was detected above the MCL in 1999 at one former Building 59 well. Benzene was detected at a concentration of 4.6 µg/L at well B59-MW03.

A discussion of BTEX compounds detected at the OU2 ROD monitoring wells during the April 2006 sampling event is presented in Section 5.0.

7.1.7 MTBE

Methyl tertiary-butyl ether (MTBE) is a colorless synthetic VOC, derived from natural gas, and is a gasoline additive to increase octane level, boost engine performance, and ostensibly improve air quality by reducing carbon monoxide and ozone levels in the air. The October 2000 sampling event was the first time VOC samples were analyzed for MTBE. Since then, only one well [NEA-MW37-1D (OU10)], has had a detection of MTBE. All detected concentrations of MTBE in this well have been at estimated concentrations below the reporting limit of 5.0 µg/L. Detected concentrations have ranged from 0.50 µg/L (April 2006) to 0.64 µg/L (October 2002). Well NEA-MW37-1D is located behind a blast shield and between Taxiway B and Runway 5R (Figure 7-5). An MCL for MTBE has not been established.

7.2 Contaminant Concentration Trends by Investigation Area

The analytical data from the April 2006 LTM sampling event indicate that the concentrations of TCE, PCE, total 1,2-DCE, and vinyl chloride in groundwater are generally decreasing or are consistent with the Baseline event in April 1998 in most of the investigation areas. Trends in these VOC concentrations specific to each investigation area are discussed below.

7.2.1 Former Building 59 Complex

At the former Building 59 Complex, TCE and total 1,2 DCE groundwater concentrations were steadily increasing in well B59-MW02 through the April 2005 LTM event. On June 8 and 9, 2005, an injection of potassium permanganate was performed to evaluate the in situ treatment of the VOC source area in the foundation of the former Building 59 basement. The results of this test were presented in a separate letter report and summarized in the October 2005 LTM report. Evidence of the permanganate (purple color) was still visible in water samples collected in the January and April 2006 and this well was not sampled during the April 2006 LTM event.

TCE and total 1,2-DCE concentrations in well B59-MW03 decreased from the October 2005 concentrations observed after the oxidant injection in well B59-MW02 (Table 6-2). Figure 7-1 illustrates the approximate extent of the April 2006 TCE and vinyl chloride concentrations in groundwater at the former Building 59 Complex. The VOC plumes are still thought to be centered over B59-MW02 as the exact radius of influence of the injection is not known. At well B59-MW04, total 1,2-DCE and vinyl chloride concentrations have decreased to pre-injection concentrations of 4.2 µg/L and 1.2 µg/L, respectively. Total 1,2-DCE detections at well B59-MW03 are still consistent with previous concentrations that have ranged from a high of 406

µg/L in April 1999 to a low of 61.2 µg/L in October 2002. Figure 7-2 shows the approximate location of the total 1,2-DCE groundwater concentrations at the former Building 59 Complex during the April 2006 sampling event.

The suspected source of the contamination (sludge from the sumps and the oil/water separator) was removed over the period of March 24 through April 7, 1999. An additional source removal of 347 tons of VOC contaminated soil was removed in April 2001. After the building removal was complete, the site was back-filled with soil, re-graded, and paved in March 2001 (IT, 2002d). This removal action is described further in Appendix A4. Monitoring wells B59-MW02 and B59-MW03 are completed entirely into the limestone bedrock to depths of 31 and 20 feet, below ground surface (bgs), respectively. Monitoring well B59-MW01 has 5.5 feet of screen in the unconsolidated overburden and 4.5 feet of screen in the weathered limestone bedrock. Well B59-MW04 is screened six feet in the overburden and four feet into weathered bedrock. Wells B59-MW01 and B59-MW04 are completed to depths of 15.5 and 17.5 feet, bgs, respectively.

7.2.2 Former Buildings 79 and 95 Complex

The four monitoring wells at the former Building 79/95 Complex were installed in February 2002 as part of the facility SI (Appendix A4) and continue to be sampled semiannually under the LTM program. TCE is the primary COC at this site and since September 2002, the TCE concentration has increased in the downgradient well (B79C/D-MW01) to 47 µg/L during April 2006. TCE concentrations in the middle two wells remain consistent with historic concentrations and above the MCL of 5 µg/L (Table 6-2). Upgradient well B79C/D-MW04 has also had increasing concentrations of TCE. Figure 7-3 illustrates the approximate extent of the current TCE plume and geologic cross-section line A – A'. Figure 7-4 is a geologic cross section showing the vertical distribution of TCE through the former Building 79 area.

The Mann-Kendall Trend Evaluation statistical analysis was performed on groundwater data from four wells at the former Buildings 79/95 Complex (Appendix L-2). Results of the evaluation indicate that TCE concentrations in wells B79C/D-MW01 and –MW04 were increasing and designated as "expanding". Trends in the remaining two wells indicate "stable" TCE concentrations.

7.2.3 Burial Sites 5 and 6

Since 1997, PCE has been detected at wells BS5 P-3 and P-4 at concentrations that have consistently ranged from 16 µg/L to 33 µg/L. Well BS5 P-3 is screened in the same water bearing zone as deeper well BS5 P-4 and has approximately the same analytical results as well P-4. Figure 7-4 illustrates the plume around the P-3 and P-4 well cluster. Well BS5 P-1 has had an average PCE concentration of approximately 1 µg/L since November 1998. PCE has never been detected in well BS5 P-2. PCE concentrations in BS5 P-3 and P-4 have been decreasing and or remaining stable since monitoring began. The Mann-Kendall Trend Evaluation was not performed on the BS5 wells.

VOCs have never been detected at BS6 P-1. Well BS6 P-2 historically has had sporadic detections of BTEX compounds at concentrations below the MCLs (Figure 6-26). April 2002 was the last time a BTEX compound was detected at this location.

7.2.4 OU2 and OU3

At OU2 and OU3, TCE has either not been detected or has been detected below the MCL since the 1992 and 1993 sampling events. In the vicinity of OU2 well NEA-MW27-3I, a wetland pump-and-treat remediation system has been in operation since the summer of 2000. As seen in Table 6-2, PCE concentrations have been approximately stable since the October 2003 sampling event including the April 2006 concentration (6.7 µg/L). Future sampling will determine if the system will reduce PCE concentrations to below the MCL. This location is included in the plume that extends through much of OU10 (Figure 7-5). VOCs have not been detected in well NEA-MW34-2S since December 1992 (15 µg/L).

TCE concentrations have been stable in two of the three wells at the 05-DM-123 cluster since July 1993 when these wells were first sampled. TCE concentrations in wells 05-DM-123S-M and -123I-M have consistently ranged between 1.5 and 3 µg/L over this period. These wells are also screened through approximately the same water bearing zone at intervals of 5 to 15 ft, bgs and 20 to 25 ft, bgs, respectively. VOCs have not been observed in well 05-DM-123D-M since TCE was detected at 1.6 µg/L in October 1998.

7.2.5 OU4

Figure 7-6 illustrates the approximate extent of the current TCE plume. During the April 2006 monitoring event, TCE was detected at concentrations consistent with the past two monitoring

events at wells OU4-MW-02B, -MW-03B, -MW-03C and -MW-12B (Table 6-2). In addition, TCE concentrations remained below the MCL at wells OU4-MW-03B, -MW-03C and -MW-12B. Overall, the OU4 area shows that VOC concentrations have been stable or are generally decreasing since the Baseline event. The exception is well OU4-MW-12B, where PCE concentrations have increased slightly since the Baseline event. Over the same time period, TCE concentrations have decreased at OU4–MW-12B from 11 µg/L in 1998 to the current concentration of 4.4 µg/L (Figure 6-34).

The Mann-Kendall Trend Evaluation statistical analysis was performed on groundwater data from three OU4 wells with elevated TCE levels and one well with elevated PCE levels (Appendix L). Results of the trend evaluation indicate that all TCE trends in wells OU4-MW02B, -MW03B and –MW12B were decreasing and designated as "stable" (Table L-3). The PCE concentrations in well –MW12B however, indicates a continued "expanding" trend.

VOCs have not been detected in well OU4-MW04B (replacement well for OU4-MW04A) since it was installed during the RI in 1993.

7.2.6 OU5 (FAA-A)

TCE concentrations at OU5 remained consistent with recent sampling rounds with the exception of well CW05-055. The TCE concentration in well CW05-055 has decreased from 15 µg/L to estimated concentrations below 1 µg/L including the current monitoring event. As seen in Figure 7-7, TCE appears to occur in two separate plumes. One plume emanates from LF5 and is centered on extraction well EW-1 and monitoring well CW05-085. Concentrations of TCE in wells CW05-055, CW05-085, HD-11, MW131S, and MW131M have historically decreased after the GWTS was placed in operation in December 1991. After the first few years of GWTS operation, TCE concentrations in these wells reached relatively constant levels. Since the permanganate injection pilot test was conducted in June and July 2000 (IT, 2001c), TCE concentrations have increased at wells CW05-055 and HD-11 during the subsequent sampling events in 2001 and 2002. Since 2003, concentrations have dropped at both wells to the current concentrations of 0.31 µg/L and 5.4 µg/L, respectively. In addition, TCE concentrations have begun to decrease at well CW05-085 over the past several sampling events to the current level of 13 µg/L. At wells MW131M and MW131S, TCE concentrations have decreased since the permanganate injection pilot test to either estimated concentrations below the reporting limit or were not detected.

The other TCE plume is centered on Huffman Preserve well MW132S (31 µg/L). At well MW132S, current TCE concentrations are consistent with those detected since 1992. Figures 7-8 and 7-9 are geologic cross sections A-A' and B-B', respectively, through the OU5 area. Cross section locations are shown on Figure 3-2. Figure 7-8 shows the vertical distribution of the TCE in the downgradient direction, from the landfill toward Huffman Dam. On Figure 7-8, the two plume centers previously delineated on Figure 7-7 are clearly shown. Figure 7-9 presents a cross-gradient view of the TCE plume immediately downgradient of EW-1.

PCE concentrations in groundwater at FAA-A are distributed between two plumes (Figure 7-10). One plume is centered on well HD-12S and has been consistently decreasing in size. The other PCE plume occurs at well MW132S. PCE concentrations have recently stabilized below the MCL. Historically these two plumes have been connected as one plume. However, due to the decreasing trend in the PCE concentration at MW132S (3.0 µg/L) and the estimated concentration at well MW131S (0.57 µg/L), there are now two plumes (Table 6-2).

As seen in Figure 7-10, the current vinyl chloride plume is centered on well CW05-085 with all detected concentrations below 1.0 µg/l. Prior to the injection pilot test, vinyl chloride had been intermittently detected at well HD-13S and since then, it has been consistently detected with some concentrations exceeding the MCL (Table 6-2).

The particle track plots presented in Chapter 6 indicate the extent of the capture area of EW-1 and the effectiveness of the groundwater treatment system at LF5. The vicinity of well MW132S, however, appears to be outside of the EW-1 capture zone and VOC concentrations are not being affected.

The Mann-Kendall Trend Evaluation statistical analysis was performed on groundwater data from four wells downgradient of LF5 (FAA-A) (Appendix L). Results of the evaluation indicate that TCE concentrations in wells CW05-55, CW05-85 and HD-11 were stable (Table L-4). These wells are located in the immediate vicinity of extraction well EW-1 and within the zone of capture (Figures 3-9 through 3-14). In well CW10-55, TCE concentrations have increased to over the MCL (5 µg/l) the last two monitoring events and this indicates an expanding trend.

In addition, TCE and PCE data from well MW132S were also evaluated by the Mann-Kendall test. As seen in Table L-6, TCE concentrations have gradually increased since monitoring period 10

which indicates an "expanding" trend over the last evaluation period (9 to 16, semiannual periods). Over the entire evaluation period however (16, semiannual periods) the overall trend is considered consistent with previous levels and is "stable". Continued semiannual monitoring will identify any continued changes in the TCE concentrations at wells MW132S and CW10-55, and an additional upgradient monitoring well to determine a potential source area may be required.

7.2.7 OU8

VOCs at OU8 were either not detected or were detected at concentrations below the reporting limit during the April 2006 event. February 1995 was the last time a VOC was detected above the MCL in this area. At well CW03-77, TCE and PCE concentrations have stabilized at below 1.0 µg/L over the last six sampling events.

7.2.8 OU9

The highest VOC concentration detected at OU9 during the April 2006 sampling event occurred at well EFDZ4-MW06 where 1,2-DCA was detected at 2.9 µg/L The current concentration is consistent with previous events and remains below the MCL (5 µg/L). Since the Baseline event, no other VOCs have been detected above the MCL at this location. At the other OU9 well, EFDZ9-M575, concentrations of total 1,2-DCE, PCE and TCE were detect at 1.0, 1.7, and 1.3 µg/L, respectively, and remain stable at levels below their MCLs (Table 6-2).

7.2.9 FAA-B (Spill Site 11)

At FAA-B, VOC concentrations in all wells have decreased or have remained consistent with recent LTM sampling events (Table 6-2). At well SP11-MW03, concentrations of total 1,2-DCE, TCE, and vinyl chloride have risen from the April 2004 levels. The approximate location of the April 2006 TCE and vinyl chloride plumes are shown on Figure 7-11. Concentrations of total 1,2-DCE did not exceed the MCL (70 µg/L) and have not been contoured. The approximate distribution of total 1,2-DCE is similar to that of vinyl chloride. Five wells had vinyl chloride concentrations exceeding the MCL during this event. In addition, vinyl chloride concentrations in side gradient wells SP11-MW01 and SP11-MW08, and downgradient well SP11-MW09 have deceased compared to the 1999 pre-injection levels.

Since the initial sampling at FAA-B in 1995, significant downgradient movement of VOCs has not been observed. In October 1999 an in-situ treatability test was conducted to determine the

feasibility of injecting oxidizers to treat the VOC contamination. The treatability test is further discussed in Appendix A4.

Well EFDZ2-MW03 was incorporated into the FAA-B monitoring well network in April 2000 to monitor potential downgradient migration of VOCs. Since that time only trace concentrations of total 1,2-DCE and TCE were detected in April 2001, no other VOCs have been detected since that time.

The Mann-Kendall Trend Evaluation statistical analysis was performed on groundwater data from five wells downgradient of Facility 92 (FAA-B) (Appendix L). Results of the evaluation indicate that vinyl chloride concentrations in four wells (SP11-MW01, -MW03, -MW07, and –MW08) were stable and consistent with recent rounds of sampling. Wells –MW03 and –MW08 are located downgradient and adjacent to Facility 92, well –MW01 is to the south side of the facility, and well –MW07 is located within the facility boundary (Figures 7-11). In addition, the TCE concentration trend in well SP11-MW09 was also evaluated. As seen in Table L-7, TCE concentrations in this well had been increasing over the first eight years of sampling as indicated by the "expanding" trend designation. During the April 2006 sampling round the TCE concentration was similar to April 2005 and the trend was designated as "stable" by the Mann-Kendall evaluation. Continued annual monitoring at FAA-B will indicate if these stable trends continue.

7.2.10 OU10/CHP4

VOC concentrations in well CHP4-MW01 have decreased to only a PCE concentration of 0.87 µg/l (Table 6-2). The TCE concentration in well 23-578-M has decreased to 3.6 µg/l and remains below the MCL for the second consecutive monitoring event. Figure 7-12 shows the approximate extent of the TCE plume at OU10/CHP4, which is centered on well 23-578-M. Figure 7-13 illustrates the approximate extent of the two PCE plumes in the CHP4 vicinity. The plume near the Base Medical Center is centered on well GR-330. This well has had consistent detections of PCE since 1993. The northern plume is centered directly adjacent to CHP4 on well 23-578-M. As seen in Figure 7-14 the two plume areas are separated by a bedrock ridge (IT, 1996).

7.2.11 OU10

The primary COCs in OU10 (and OU2) are PCE and TCE (Table 6-2). Of the eleven OU10 wells monitored four wells have primarily PCE contamination, three wells have primarily TCE contamination, two wells have had consistent levels of both, and in two wells PCE and TCE have not been detected. VOC concentrations at OU10, including the April 2006 levels, have been stable to generally decreasing since the Baseline event. Figure 7-5 shows the current PCE and TCE plumes through OU10 and beginning in OU2. The PCE plume is centered between OU2 well NEA-MW27-3I and OU10-MW11S. The TCE degradation daughter products 1,2-DCE and vinyl chloride have never been detected at these OU10 wells.

Monitoring well GR-334 had TCE detected during the RI (August 1994) at a concentration of 7 µg/L. Since that event VOCs have not been detected in this well. Well NEA-MW37-1D had initials detections of the BTEX compounds in August 1993. Since that event VOCs have not been detected in this well. MTBE has been detected at trace amounts (below 1 µg/L) for approximately four years.

7.3 Inorganic Analytical Results

The following section presents an evaluation of the inorganic analytical results from the April 2006 LTM sampling event. Dissolved metals (filtered) results from the April 2006 LTM sampling event (Table 6-3) are discussed in each section. The total metals concentrations for April are compared to historical total metals concentrations (Tables 6-4 through 6-7). Table 6-8 summarizes the April 2006 LTM total metal (unfiltered) sampling results. The dissolved and total sample results are compared to determine whether contaminants are present in the mobile dissolved phase, or attributed to suspended soil particles in unfiltered samples. Current and historical results are compared to evaluate contaminant trends since the RI event.

7.3.1 OU2

During the April 2006 sampling at OU2, total chromium was detected in well NEA-MW24-2S (550 µg/L) at a concentration above the MCL and Layer 1 "Outwash" RG (100 µg/L) (Table 6-4). Total chromium has been consistently detected above the RG at this location since April 2001. Since the Baseline sampling in April 1998, total chromium and nickel have intermittently been detected at concentrations exceeding their respective RGs at OU2. The remaining inorganics were either not detected or have been detected below RGs since the Baseline event. Overall, the

majority of the metals contamination initially detected during the OU2 RI groundwater sampling has not been present in subsequent sampling events.

Dissolved chromium was not detected at well NEA-MW24-2S during the April 2006 event (Table 6-3). This indicates that the elevated concentrations in unfiltered samples may be attributed to soil particles in samples rather than to contaminants being present in the mobile dissolved phase or colloids.

7.3.2 OU3

As seen in Table 6-3, during the April 2006 sampling event, arsenic was detected in the dissolved metals sample at a concentration of 12 µg/L, which is above the MCL (10 µg/L). Detected concentrations of total metals concentrations at well 07-520-M were all below the associated RGs (Table 6-4). Arsenic was not detected in the total metals sample (Table 6-4).

7.3.3 OU5

At OU5, manganese was detected in well CW15-055 at a total concentration of 470 µg/L and a dissolved concentration of 510 µg/L. Both concentrations are above the RG (134 µg/L). Total manganese has been detected at concentrations above the RG since 1993 (Table 6-5). The similar total and dissolved concentrations of manganese indicate that this contaminant is present in the mobile dissolved phase rather than in suspended soil particles. An MCL for manganese has not been established.

7.3.4 OU8

Detected total metals (aluminum, antimony, barium, and manganese) at OU8 were below associated RGs during the April 2006 event (Table 6-8). The concentrations of the inorganic COCs initially detected during the RI sampling in 1995 have decreased to below the RGs or have not been detected (Table 6-5). As seen in Table 6-3, detected dissolved metals, aluminum, barium and manganese, at OU8 were below associated RGs during the April 2006 event.

7.3.5 OU9

At OU9 no metals were detected above their associated RGs or MCLs. It was determined through a geochemical statistical evaluation (Shaw, 2004b) that previous elevated metals detections in OU9 monitoring wells EFDZ8-MW01 and EFDZ10-MW02 (P4-2) were naturally occurring. Both wells were completed in semi permeable material that had a very low hydraulic conductivity

and were not representative of a water bearing unit. These wells were abandoned in early April 2004.

7.3.6 OU10

As seen in Tables 6-3 and 6-8, dissolved and total inorganics of concern were not detected during the April 2006 event. Additionally, the inorganic COCs monitored at OU10 have never been detected above an RG during any of the previous LTM sampling rounds (Table 6-7). The metals contamination initially detected during the OU10 RI groundwater sampling have not been observed in subsequent sampling events.

7.4 Conclusions

Based on the analytical results presented in Chapter 6 and discussed in Chapter 7, continued monitoring is recommended for all existing wells in the Basewide LTM monitoring well network. In accordance with requirements presented in the revised WPAFB QAPP (Shaw, 2006), the Mann-Kendall Trend Evaluation statistical analysis was performed on groundwater data from wells at selected sites where multiple wells have historically had VOC detections above an MCL (Appendix L)

At FAA-B (Section 7.2.9) VOCs have not been detected in monitoring well EFDZ2-MW03 for five years. Therefore it is recommended that this well be deleted from the annual LTM well network

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LEGEND:

- MONITORING WELL SAMPLED ANNUALLY
- MONITORING WELL SAMPLED SEMI ANNUALLY
- WATER LEVEL MONITORING WELL NETWORK
- EXTRACTION WELL LOCATIONS
- A A' LITHOLOGIC CROSS-SECTION LINE
- —x—x— FENCE

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SCALE: 1"=300'

0 100 200 300 600

Shaw™ Environmental, Inc.

WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Figure 2-2
Landfill 8 Site Map

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